

A STUDY OF MORTALITY AND MORBIDITY
IN THE
POPULATION OF A ZOOLOGICAL PARK

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1

A STUDY OF MORTALITY AND MORBIDITY
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"Next to the production of domestic animals and the cultivation of plants, keeping wild animals in zoological gardens affords the oldest example on the most grandiose scale of man's activity in experimental biology." H. Hediger.

INTRODUCTION

In many respects a zoological collection offers unusual opportunities for the study of animal mortality and morbidity. Animals are kept in small groups, in a fairly constant environment, and under closer individual scrutiny than even most domestic animals except perhaps the dog, the riding horse and the dairy cow. Although many species are too dangerous to permit examination by handling, this is to some extent balanced by the possibility of obtaining exact information of the behaviour of each individual animal, e.g., the state of its appetite and the nature of its excreta. Theoretically, therefore, it should be possible to keep a complete record of each animal's history from the date of its arrival at, or birth in, the park, until the day of its death or departure. There are many practical difficulties in the way of this, however, and few Zoological Societies are in a position to provide the staff or facilities that such a scheme would require.

The two Zoological Societies which have long been predominant in the study of disease in Captive Wild Animals, are those of Philadelphia and of London. H. Fox of Philadelphia in 1923 published his work "Disease of Captive Wild Mammals and Birds" which is analysis and discussion of the detailed records

kept by that Society during the early years of the century, and, to the writer's knowledge, this is the only detailed and complete study of the subject in existence. Both Societies publish detailed reports annually, recounting the disease picture during the preceding year, and that of H. E. Hamerton at London published in 1939 contains an analysis of the principal causes of death for a ten year period. Vincennes Zoological Park in Paris also publishes a detailed annual report of births, deaths and disease, and the New York Society a more brief account. The majority of other Societies do not appear to do so. In general, the remaining literature on the subject consists of papers published by the pathologists, veterinary surgeons and others who have worked at the various zoological collections.

A brief study of the mortality picture in the Edinburgh collection was prepared for the Royal Zoological Society of Scotland by the late Professor Mathieson of the Royal (Dick) Veterinary College. It consisted of a comparison between the principal causes of death in birds and mammals during the two years 1935 and 1945. Some three hundred post-mortem reports are considered under fourteen broad headings, but the study was not carried out in detail in view of a larger survey which was apparently in course of preparation at the time of the Professor's death.

The advantages to a Zoological Society of an exact knowledge of the diseases occurring among its own stock are many. Apart from the financial losses incurred and the difficulty of replacing valuable animals, other issues are involved.

There are many who criticise the existence of zoological collections on moral grounds. Hediger, in his book "Wild Animals in Captivity," had dispelled many of the anthropo-

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morphic fallacies used by these critics, but he does stress the importance of an attempt to establish optimum conditions for captive wild animals. These optimum conditions are in many cases unknown, and the only way in which an understanding of them can be arrived at is by careful scientific study of the diseases which occur in zoological collections.

The results of a scientific careful investigation may also be of value in related fields of veterinary pathology, parasitology and hygiene, and even in the realm of human medicine. At the same time many specimens, which would otherwise be wasted, are made available to comparative anatomists and others.

Finally, there is the fact that healthy and well-developed animals form the best exhibits from an aesthetic, educative and artistic point of view.

Method of Study

Until the writer's arrival in October 1949, in receipt of an Animal Health Trust fellowship, The Royal Zoological Society of Scotland employed no veterinary officer. Clinical work was carried out by the clinicians of the Royal (Dick) Veterinary College, and all important mammals and birds, and some reptiles which died were submitted to the pathological laboratory of that institution and on occasion to the anatomy and pathology departments of Edinburgh University. The reports of these examinations were abstracted briefly, sometimes inaccurately and with some omissions, into a ledger. From the year 1938 onwards, however, a complete file has been kept of the original post-mortem reports and these have been available for study. Some earlier reports are also in the writer's possession, but in the main are too brief to be of value.

Since October 1949 the writer has been responsible for almost all the clinical work and post-mortem examinations, and since October 1950, when the Principal of the Royal (Dick) Veterinary College kindly granted him laboratory facilities, he has been responsible for histopathological examinations as well. Bacteriological work has been done throughout by the college laboratories and parasitological investigations by the staff of the Zoology Department of Edinburgh University.

In view of the unsatisfactory nature of the records preceding 1938 they have been (with the exception of those concerning the penguins) excluded from the present study which therefore covers two distinct periods:-

1. The period 1938-49, the material concerning which consists of nearly 2,000 post-mortem reports on mammals, birds and reptiles. These are the work of a number of different

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pathologists in the Departments of Pathology and of Poultry Pathology at the Royal (Dick) Veterinary College and in the Anatomy and Pathology Departments in the University of Edinburgh. In some cases these workers were not specialists on the subject of wild animals and, in addition, they were usually not supplied with information of the animal's history before death. In consequence many of the reports are brief and lacking in detail, but it was felt that such a large series would well be worthy of careful analysis.

As every animal that died was not submitted for post-mortem, these reports do not enable a calculation of death rate for these years.

2. The period 1950-51, the material available for study including clinical observations made upon the animals in the Edinburgh collection and the results of the post-mortem examination of all mammals, birds and reptiles during the period, a complete list of which is appended.

Histological sections were prepared and stained in cases where required by the laboratory staff of the pathology department of the Royal (Dick) Veterinary College and, as stated above, were examined and reported upon by the pathologists there, until the writer was enabled to take over the examination of them in October 1950.

In addition to clinical and pathological work, the writer has also been responsible for the preparation of annual of inventories of stock, /annual and quarterly reports and the preservation and dispatch of scientific material to a number of institutions (a list of which is appended). A card index has also been prepared and maintained covering the clinical history of individual mammals, birds and reptiles as far as is practicable.

Plan of the Thesis

The study, made by Fox, of the mortalities at Philadelphia provides a detailed picture of the pathological changes occurring in wild mammals and birds, intended primarily as a basis for comparison with human pathology. The book deals with the various systems and organs of the body, and although comments are made upon the differences in disease processes observed between the classes and orders of animals, this is not the primary purpose of the work.

The present thesis is planned from a somewhat different aspect. Each order of mammals, birds and reptiles has been studied separately and the section devoted to each order is in two parts. The first concerns the period 1938-49 and the second the period 1950-51. Discussions are given for each of the mammalian orders and for the three classes, mammals, birds and reptiles. In view of the importance of penguins to the Edinburgh collection, a special section is devoted to an analysis of their mortality extending back to 1917. In addition to this, a short statistical study of mortality in relation to population and a comparison with the figures available for other zoological collections is included. A concluding discussion ends the paper. The photographs were taken by the technical staff of the Pathology Department of the Royal (Dick) Veterinary College from the writer's preparations of material. In addition to the other appendices, a table indicating the form of classification employed has been included.

The fifteen categories into which all mortalities have been divided have been selected with care, the first seven concerning anatomical regions affected, the remainder etiological factors. When the actual cause of the condition is known, the

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the subject is included in one of the latter categories.

Bacterial diseases are, however, only included in the "Special Disease" section if they are generalised.

Each animal is included in the tables only once, as it is felt that the introduction of secondary findings would render the whole picture unduly complicated. They are referred to in the text, however, for all mammals.

All tables concern post-mortem findings, not necessarily causes of death, as these are by no means always definitely established. Only those cases where no abnormality has been found that could possibly have been responsible for death have been included in the "Inconclusive" column. The categories "Tuberculosis" and "Neoplasia" have been given precedence over the other categories because of their importance. That is to say, a few cases have been included in these columns although the tuberculous or neoplastic lesions found were not those principally concerned in causing death. Needless to say, many difficulties have arisen, especially concerning the 1938-49 period, in deciding which of the abnormalities seen or reported were of principal importance. Every effort has been made to be consistent and logical in every case. Considering the number of cases dealt with, it is felt that some at least of those mistakes which must necessarily occur in an analysis of this type, will have cancelled each other out.

There is no practice at Edinburgh of marking mammals or of ringing birds, thus comparative discussion of the mortality picture in new arrivals compared to old stock has not always been possible.

The National Zoological Park of Scotland

The Zoological Park is owned and administered by the Royal Zoological Society of Scotland. The Society was founded in 1909 and incorporated by Royal Charter in 1913, in which year the park was first opened. The Fellows of the Society elect a council, which also includes representatives of the Edinburgh City Corporation, and the Council in turn appoints a Director-Secretary, who is responsible for the control of the park.

The only sources of income are gate receipts, subscriptions, legacies and profits from catering and the sale of guide-books, etc.

With the exception of the London Zoological Gardens, the collection of animals is probably the largest, and certainly the most representative of any in the British Isles.

Brief Description of the Park (Also vide Gillespie 1938)

The park occupies an area of 74 acres on the southern slopes of Corstorphine Hill in Western Edinburgh and adjacent to this are a further 25 acres available for possible future expansion.

The accompanying sketch map indicates the layout of the area at present in use. The higher land is divided into three large grass paddocks and several small rocky enclosures. The lower portion is largely 'built-up' with roads and animal houses, but there are also a number of small grass paddocks and natural rock enclosures. Two artificial chains of pools have been installed in this area, the water being circulated by mechanical means. Thus all types of animal management, with the exception of really large area grazing, are practised side by side. This does not only apply to the different types of

animals, but also to the same type. For example, some deer are kept in the large North Eastern enclosure receiving little food but natural grazing; others are kept in houses with a small grass paddock attached and receive a concentrate supplement to the limited grass available; and yet others are kept in concrete floored yards and are entirely hand fed. This means, of course, that there is a different environment to be considered in almost every case of disease.

A short paragraph is included at the beginning of each section in the following study, describing the type of management most commonly employed for the animals mentioned.

The visitors have close access to, and are consequently able to feed, almost all the stock excepting the inhabitants of the reptile house and aquarium.

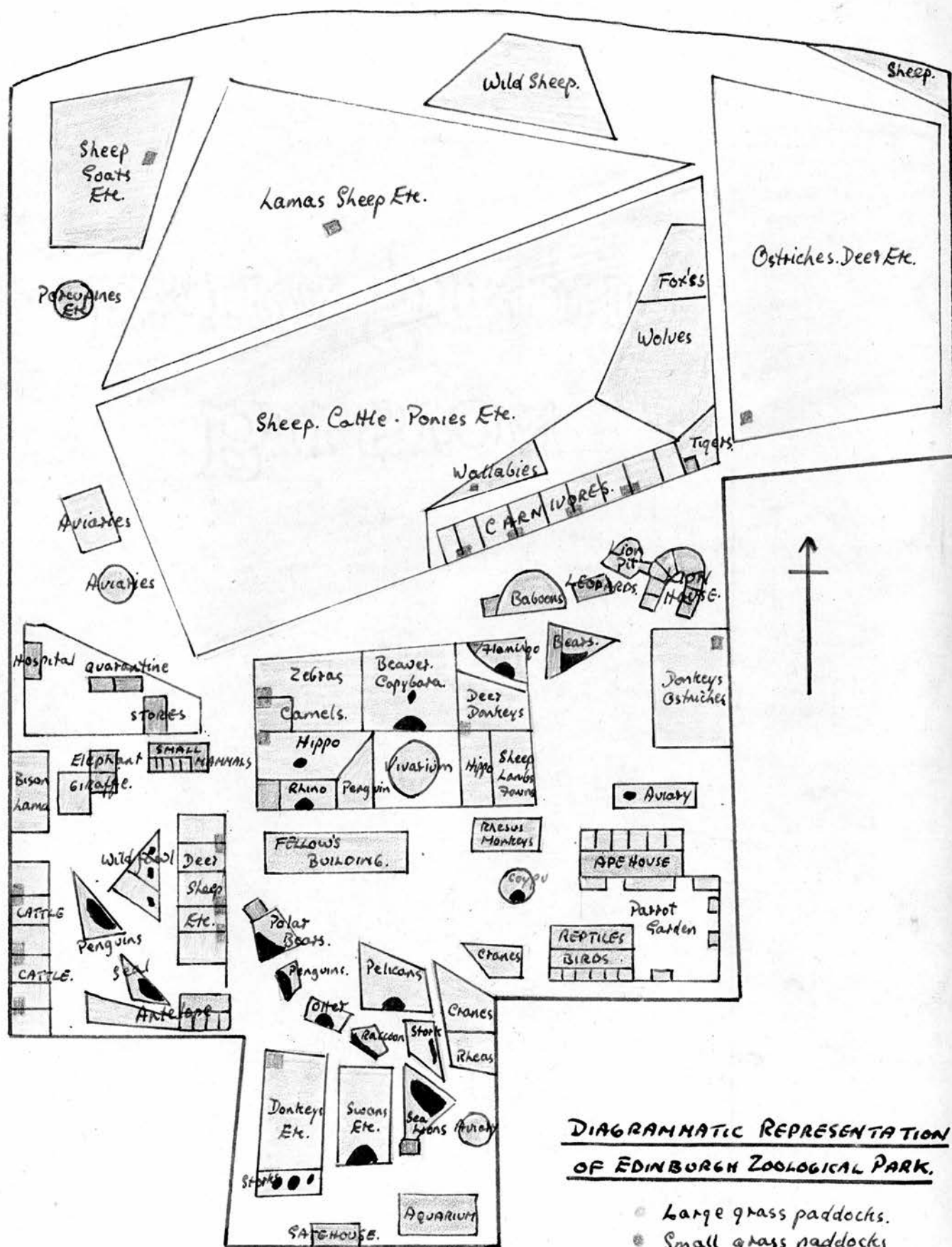
The hill on which the park is situated rises to a height of 550 feet, the pasture being fair quality permanent hill grazing with numerous outcrops of whinstone and clumps of furze on the higher ground. The steep slope ensures good drainage over most of the area.

Climate

It has been stated that "Edinburgh's climate is markedly more maritime than that of south-eastern England." It is a climate subject to sudden changes in temperature with, in the main, cool summers, fine autumns, relatively mild winters and changeable and unpleasant springs. Extremes of heat and cold are rare and the prevalent winds are from the West and from the East owing to the city's position in the Forth-Clyde gap. The figures given are for Blackford Hill, which is not dissimilar in height and situation to Corstorphine Hill on which the zoological park is situated.

	Jan.	Mar.	May	July	Sept.	Nov.	Year
<u>Temp. (°F).</u>							
Average	39	40	49	58	53	42	47
Mean Daily Max.	43	45	55	64	59	46	52
Mean Daily Min.	35	35	43	51	48	38	42
Extreme Max.	57	67	76	83	79	63	83
Extreme Min.	14	21	30	42	33	18	14
<hr/>							
Precip. (Inches)	1.8	2.0	2.1	2.8	2.1	2.2	26.3
Sunshine (hrs/day)	1.5	3.5	5.3	5.3	4.3	2.2	3.7
Days with thunder	0.1	0.1	0.8	1.8	0.5	0.1	6.4
Days with snow	4.9	4.8	0.5	-	-	1.2	20.9

(This information is abstracted from the "Scientific Survey of South Eastern Scotland," published for the British Association at Edinburgh in 1951.)



- Large grass paddocks.
- Small grass paddocks
- Solid floored enclosures
- Heated houses
- Unheated houses
- Pools.

AN ANALYSIS OF THE CAUSES OF MORTALITY AND MORBIDITY
AMONG THE VARIOUS TYPES OF STOCK
IN THE EDINBURGH ZOOLOGICAL PARK
DURING THE YEARS 1938 - 1951

SECTION A : CLASS MAMMALIA

ORDER: PRIMATES

This order includes the Great Apes, the Old and New World Monkeys, the Lemurs and the Pottos, Galagos and Lorises, etc. These groups differ more widely from one another than do the subgroups of most other orders and therefore the families are considered separately.

FAMILY : PONGIDAE

Of the three species of great apes, only chimpanzees (*Pan satyrus*) and orang-outans (*Pongo pygmaeus*) have been kept at Edinburgh. Each ape or small group of apes is confined in a pair of cages connected by a passage, one cage being indoors and separated from the visitors by bars and a glass screen, and the other outdoors and incompletely separated from the visitors by bars and a hedge. The apes have direct contact with one another outside through the bars separating the cages and indirect contact inside by a common drainage channel running along the feeding passage and a common airduct above the cages.

Their food is cooked flaked maize, bread, potatoes, onions, lettuce, tomatoes, bananas and other fruits and vegetables.

The apes are expensive animals to buy, to house, and to

feed and only a small number are kept at one time. The number of deaths is small and the reports, therefore, can be considered individually.

Period 1938-49

There are six reports of post-mortem examinations of Chimpanzees:-

- No. 1. Young male "Poohbah": Lobar pneumonia and bronchitis due to infection with type III Pneumococcus.
- No. 2. Two-year old. Acute pneumococcal bronchopneumonia.
- No. 3. Adult female "Juliet": Generalised tuberculosis. The route of infection was apparently intestinal, the report reading: "Large masses of tuberculous glands found in root of mesentery and around head of pancreas. Fibrin and pus in peritoneal cavity shut off in local pockets by peritoneal adhesions. Miliary tubercles also found in kidneys and larger caseating areas in spleen. Enlarged glands in axilla and neck. Lungs healthy apart from glands at root and some terminal consolidation."
- No. 4. Young male "Hansel": Perforating ulceration of colon, the cause of which was undiscovered.
- No. 5. Old male "Flanagan": Cellulitis of leg with gangrene subsequent to septic phlebitis.
- No. 6. Female "Bunty": Acute non-specific enteritis. Chronic peritonitis. Sub-acute focal glomerulo-tubular nephritis. Alveolar emphysema of apices and ventral borders of lungs.

There are two reports of examinations of orang-outans:-

- No. 1. Young orang born a few days previously died from maternal neglect.

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No. 2. Adult female. Died from exhaustion while attempting to give birth to an incorrectly presented foetus (Breech presentation).

Period 1950-51

Three chimpanzees were the only deaths during this period:-

P50/10 One-year old female 'Carol'. This young animal was undernourished, the parent female having only one active mammary gland. It contracted a severe 'cold' during the winter months, the typical catarrhal nasal discharge persisting for about a week. A few hours after the animal had been seen breathing normally it was found prostrate with severely laboured respiration. The nose appeared to be blocked and it died shortly after, while being roughly handled by the parents. No medication or post-mortem examination was possible as it could not be separated from its parents until several days after death.

P50/3 Young male 'Bobby': This animal died and was examined post-mortem during my absence, the cause of death being reported as bronchitis with subsequent extensive bronchopneumonia.

P51/1 Eighteen-year old male 'Sam': Death was sudden and without any premonitory symptoms. On post-mortem examination the principal findings were a vegetative endocarditis, severe pulmonary congestion and emphysema and sub-serous haemorrhages. Streptococcus viridans was isolated from the lung tissue. Histological examination was reported as showing long standing

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interstitial myocarditis and acute bronchitis. There is little doubt that heart disease was primarily responsible for death and the bronchitis either the exciting cause or more probably merely terminal.

FAMILY : HYLOBATIDAE

Only a few Gibbons have been kept at Edinburgh Zoo during the years under discussion and none died during the period 1950-51. They have been housed in both the Ape and Monkey Houses and their diet is similar to both these.

- No. 1. White-handed Gibbon (*Hylobates lar*) showed acute bronchopneumonia from which *Pseudomonas pyocyanea* was obtained in pure culture.
- No. 2. Hoolock Gibbon (*Hylobates hoolock*): Young male showed a similar condition to that occurring in *Cercopithecidae* during 1949 (see below) . Infection apparently "arising from lymph follicles of small intestine. Gross secondary lesions throughout the liver."
- No. 3. Hoolock Gibbon: No abnormality found other than malnutrition.

FAMILY: CERCOPITHECIDAE

This family includes all the old world monkeys, i.e., Guenons, Macaques, Mangabeys and Baboons, these forming the bulk of the primates exhibited at Edinburgh and most other European menageries.

The type of housing varies greatly. The Rhesus Monkeys (*Macaca mulatta*) are housed outdoors throughout the year in a large cage with a grass covered floor; some Baboons and other monkeys are kept on the 'Baboon Rock' with a heated

indoor sleeping enclosure and the remainder are kept in the Small Mammal House. This house has heated indoor cages and rock-floored outdoor cages, designed to allow the inhabitants a choice of environment. The outdoor cages, however, are frequently required for other stock and many monkeys may remain indoors for long periods.

The diet is similar to that given to the apes, though smaller in quantity. All monkeys have free access to feeding by the visitors. The Rhesus monkeys in the open cage spend much of their time grazing.

Period 1938-49

166 of the 201 Primate reports studied concern species of the Family Cercopithecidae so that the analysis of the post-mortem findings for the Order shown in the Table and Diagram gives a fair picture of the disease findings in this family with the exception of dietary disease affecting the skeleton (see below).

The Cardiovascular System

Two reports only concern this system.

1. A Baboon (*Papio* ?) with generalised chronic venous congestion, chronic pericarditis and "acute cardiac decompensation."
2. A Vervet Monkey (*Cercopithecus pygerythrus*) affected with pericarditis.

The Respiratory System

58 Reports mention abnormalities of the respiratory tract, but apart from the cases of pulmonary tuberculosis which are included under that heading, in only 35 reports were they the principal finding.

These 35 reports concerned 7 Patas Monkeys (*Erythrocebus patas*), 8 Vervet Monkeys, 3 Green Monkeys (*Cercopithecus sabaeus*), 4 Rhesus Monkeys, 7 Baboons (*Papio papio*, etc.) and one Grivet Monkey (*Cercopithecus aethiops*), one Mona Monkey (*Cercopithecus Mona*), one Stump-tailed Monkey (*Macaca arctoides*), one Mandrill (*Mandrillus sphinx*) and two Macaques (*Macaca* ?).

There is little value in discussing these reports individually as in most cases nothing is known of the history, and insufficient numbers of reports are available to allow study of species difference. The majority of the reports on Patas monkeys do, however, fall under this heading.

The terms used most frequently in the reports are 'bronchitis,' 'bronchopneumonia', 'purulent bronchopneumonia,' 'catarrhal pneumonia' and 'double pneumonia.' Where 'congestion of the lungs' has been the sole finding, the reports have also been included here. In no case are the results of any bacteriological examination reported.

The monthly incidence of these 35 cases is:-

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
6	6	4	3	2	2	0	2	0	2	3	5

showing a higher level in the winter months as might be expected.

Alimentary System

Excluding two reports included under Neoplasia and one under Parasitic Disease, 49 reports mention disease of the alimentary system as the principal post-mortem finding. In a further five reports it appears as a secondary finding.

The species concerned are Baboons, Patas, Green, Vervet, Rhesus and Mona Monkeys, a number of Putty-nosed Monkeys (*Cercopithecus nictitans*) and one Sooty Mangabey (*Cercocebus*

fuliginosus).

These 49 reports can be grouped as follows.

1. One of acute pharyngitis and one of dental abscess.
2. Twenty-seven reports of 'enteritis' and particularly 'colitis,' one of which mentions the isolation from the intestine of *B. flexnerii* and another the isolation of a 'dysentery bacillus.'
3. Twelve reports concerning only Green and Putty-nosed monkeys. These related cases occurred in the Small Mammal House in the summer of 1949. The disease is described in the reports as a "typhoid-like" condition, the general picture being an ulcerative enteritis, with secondary involvement of the mesenteric glands, liver and spleen. No definite conclusion was apparently reached as to the exact etiology of the condition. One related case in a Gibbon is referred to above.
4. Four reports of peritonitis mentioned as sole finding.
5. One report of haemorrhagic pancreatitis and one where the head of the pancreas was involved in an inflammatory process with the adjacent duodenum.
6. One report of acute hepatitis and one of a liver abscess.

The Urinary System

Of the six reports included here, four refer to nephritis in a Mandrill, a Macaque, a Vervet and a Rhesus monkey. Twice it is described as a simple tubular nephritis, once as an acute glomerular nephritis and once as an acute diffuse glomerulo-tubular nephritis.

The other two reports are of acute cystitis in a Baboon and inflammatory obstruction of the urethra in a Mona Monkey.

A report of urethral obstruction by a neoplasm is included under that heading and a secondary renal infection arising from a primary metritis under the Reproductive System.

The Reproductive System

In only three reports does an affection of this system figure as the principal finding. Two concern Rhesus Monkeys post-partum, one showing complete uterine prolapse and the other septic metritis and an ascending nephritis. No causal organism is mentioned in the latter case. The third concerns a Lion-tailed Macaque (*Macaca silenus*) showing cystic ovaries and pyosalpinx.

Another Rhesus monkey, dying of a respiratory infection, showed a vaginitis when examined post mortem.

The Central Nervous System

The three reports included here are:-

1. Acute meningitis of unknown origin in a Green Monkey.
2. Encephalitis in a Bonnet Monkey (*Macaca radiata*).
3. Chronic ossifying pachymeningitis in a Lion-tailed Macaque.

Other Tissues

Four reports not classifiable elsewhere are included under this heading.

1. Generalised lymphadenitis of unspecified origin in an Anubis Baboon (*Papio anubis*).
2. Anaemia in a Vervet Monkey.
- 3 and 4. Bacterial necrosis of the spleen in two Vervet Monkeys but no pathogen isolated.

Dietary Factors affecting the Skeleton

Seven reports concerning 3 Vervet Monkeys, 2 Rhesus Monkeys and 2 Bonnet Macaques mention bone disease of dietary

origin, and in all these it has been taken as the principal finding. The term 'osteomalacia' is used in three reports, 'calcium deficiency' in two and 'Rickets' and 'osteoporosis' once each.

All these cases occurred between 1939 and 1943 and were doubtless due to shortage of correct feeding stuffs.

Other Dietary Conditions

Sixteen reports describe inanition, emaciation, malnutrition, etc. as the principal finding on post-mortem examination, or else refer to a suspected dietary deficiency.

These concern 6 Baboons, 4 Green, 3 Rhesus, 2 Vervet and 1 Mona Monkey.

The majority of the cases were during the early war years and were again no doubt due to the shortage of feeding stuffs.

Parasitic Disease

The sole report ascribing the principal post-mortem findings to this cause is of a Vervet monkey grossly emaciated due to the presence of many small tapeworms in the small intestine.

In six other reports parasitic infestation is mentioned among other findings. One is of an echinococcus cyst in the liver of a Green Monkey, the other five are of unidentified cestodes and nematodes.

Neoplasia

The three reports are of pancreatic carcinoma in a Rhesus Monkey and a Vervet Monkey, and of a penial neoplasm obstructing the urethra in a Vervet Monkey.

Tuberculosis

The eight reports of this disease in the family concern ~~two~~ Vervet, one Green, one Grivet, one Rhesus and one Stump-tailed Monkey, one Bonnet Macaque and one Drill (Mandrillus leucophaeus).

In two cases the route of infection was almost certainly respiratory, pulmonary affection being associated in one with a pharyngeal abscess and in another with pleurisy and a mild peritonitis.

In two more cases pulmonary affection was associated with lesions in the spleen, and also the mesenteric lymph nodes in one of the two.

In the fifth case, an hepatic abscess of tuberculous origin is the only lesion reported.

In two other reports 'tuberculosis' is diagnosed but the lesions are not described.

The eighth report describes miliary lung lesions and a purulent arthritis and states the former to be suspicious of tuberculosis.

Special Diseases

The one report included here concerns a Green Monkey showing a septicaemia due to streptococcal infection.

Violence

Five of the eleven reports concern four Vervet Monkeys and one Baboon, all reported as showing "toxaemic cellulitis." These died during a short period but the origin of the condition is not stated.

The other six reports concern two Baboons, one Patas Monkey, one Rhesus Monkey and two unnamed Monkeys. All showed severe injuries.

Inconclusive, etc.

Comment is made in the 'Clinical Remarks' below of the symptoms seen in a Mona and a Green Monkey which on post-mortem examination showed no abnormalities whatever and are consequently included in the 17 reports classified here.

Period 1950-51

Twelve members of the Family Cercopithecidae were examined post-mortem during this period.

The Cardiovascular System

P50/6. Adult male Patas Monkey, resident in the park for some time. This animal had been lame in the hindquarters for a period. The first symptoms seen was sudden collapse with sub-normal temperature, posterior paralysis, inco-ordinate movements of arms and hands and a watery diarrhoea. Examination of a blood smear revealed an intra-corpuseular parasite somewhat similar to that of human malaria. Treatment with "Paludrene" (Imperial Chem. Indust.) was instituted without success. The only significant finding on post-mortem examination was chronic interstitial myocarditis. The histological report confirmed this and suggests the possibility of a virus as the causal agent, the absence of any hepatic or splenic lesions making it unlikely that the blood parasite was the cause.

The Alimentary System

P51/7 a young adult Putty-nosed monkey died suddenly. The only post-mortem findings were widespread hepatic fatty change and some renal tubular degeneration.

P51/4, a young Mona Monkey, died after symptoms similar to those described above in the Patas Monkey P50/6. The principal finding on post-mortem examination was an enteric congestion.

Bacteriological examinations were negative. Both these monkeys were old stock.

Special Disease

P50/8 and P50/9. Two young Hamadryas Baboons (*Papio hamadryas*), both old stock, died within two days of each other. The history of these cases is briefly as follows:-

6/10/50: A half-grown female Baboon of a different species was introduced into the cage occupied by three young Hamadryas Baboons.

13/10/50. New baboon removed from the cage after bullying the others. P50/9 showed several severe respiratory attacks resembling human asthma. These were not repeated.

15/10/50. P50/8 suddenly became prostrate with periods of loud crying, congestion of membranes, trismus and hyperaesthesia. Treated with glucose saline and 'Epanutin' (Parke Davis).

16/10/50. Partial paralysis. Further treatment given. Death during night.

18/10/50. P50/9 died after short period of listlessness.

Post-mortem examination of P50/9 showed nothing of significance. P50/8 showed some hepatic fatty change, catarrhal enteritis and general congestion of viscera. *Salmonella enteritidis* var. Dublin was isolated from the bone marrow in each case.

No further cases occurred during the period, the third young Hamadryas Baboon remaining healthy.

P50/1. An adult male Patas Monkey died during the night having been observed in apparently normal health the previous evening. Post-mortem examination showed large haemorrhages in the lungs from which *Pasteurella septica* was isolated. This monkey occupied a cage near the door of the house and the possibility

of a sudden 'chill' lowering its resistance does exist.

P51/5. A newly arrived young female Green Monkey died suddenly, revealing on examination an acute haemorrhagic enteritis. An organism resembling those of the Shigella group and which was lethal to mice was isolated from the bone marrow.

Violence

P50/4. A female Crab-Eating Macaque (*Macaca irus*) was killed by a Chimpanzee in a neighbouring cage while convalescent.

P51/3. A White-crowned Mangabey (*Cercocebus torquatus*) was killed accidentally during an escape.

Both of these were old stock.

Inconclusive, etc.

P50/11 and P50/12, two newly arrived Green Monkeys died suddenly and were examined during the writer's absence. One showed evidence of septicaemia but unfortunately no bacteriological examination was carried out. The other showed no significant post-mortem findings, but its death may have been connected with the anthelmintic dose of 'Nemural' (Beyer) given shortly before.

P51/2, an adult Patas Monkey, old stock, died suddenly showing only slight hepatic fatty change on post-mortem examination.

FAMILY CEBIDAE and FAMILY HAPALIDAE

The former includes the New-World Monkeys, Capuchins, Woolly Monkeys, Spider Monkeys, etc., and the latter the Marmosets, also residents of South America.

Their diet is similar to that of the Cercopithecidae though they receive some insect food such as mealworms in addition.

They are housed variously as the other monkeys, while some of the smaller ones are kept in the Reptile House as are the pottos, etc. (see below).

Period 1938-49

Respiratory System

Four common Marmosets (*Hapale jacchus*) are reported as dying of respiratory disease. It is understood that these tropical animals were exhibited in unheated cages in cold weather.

Alimentary System

Three Marmosets are reported as showing principally widespread hepatic fatty change.

A Spider Monkey (*Ateles* ?) is reported merely as having 'peritonitis' and a Woolly Monkey (*Lagothrix* ?) as gastro-enteritis and gangrene of the large intestine.

Dietary Deficiencies affecting the Skeleton

Three Marmosets, three Capuchin Monkeys (*Cebus* ?) and two Woolly Monkeys (*Lagothrix* ?) are reported as showing bony changes due to dietary deficiency or imbalance. The terms used were 'osteomalacia' in the case of the Marmosets and two of the Capuchins, 'rickets' in the Woolly Monkeys and 'scoliosis' and multiple fractures' in the other Capuchins.

Inconclusive, etc.

Inconclusive etc.

One report on a Marmoset.

Note: The majority of the above cases occurred during the early war years

Period 1950-51

During this period but few of these families have been present in the collection. The only deaths have been as follows.

P51/6. Black-tailed Marmoset (*Hapale argentata*) died at birth.

This is believed to be the first of this species to have been bred in Britain. The cause of death was not apparent but may have been maternal neglect due to lack of privacy.

P50/5. Common Marmoset, newly arrived. The only lesions found on post-mortem examination were a number of nodules containing minute unidentified nematodes in the wall of the caecum.

P51/11 'Andy', a male Brown Woolly Monkey (*Lagothrix infumatus*) was one of a pair of unknown age which arrived in September 1950.

'Amos' was in rather poor condition and was irradiated daily with an ultra-violet lamp for several months without apparent improvement. Both received a vitamin D concentrate and

Di-calcium Phosphate in the diet. 'Andy' was the first to show signs of progressive bone disease with swelling of joints and distortion and softening of the bones, especially of the hind legs and face. In February 7½ milligrams of vitamin D₂ were given intra-muscularly (in the form of "Zoo Sterogyl".

Roussel). A considerable improvement was noticed in the animal's general condition though the distortion of the bones did not lessen, but by the month of June it was worse again and 'Amos' was also showing signs of bone disease. Despite further massive doses of vitamin D₂ given intra-muscularly to both

monkeys and increased supplements of Calcium diphosphate the condition rapidly worsened and Andy was destroyed on humane grounds on 25/8/51. 'Amos' was exchanged before the disease had reached so severe a stage.

Photographs are appended showing the macroscopic and histological appearance of the bones, which is similar to that seen in the condition Osteodystrophia Fibrosa.

FAMILY LEMURIDAE

This includes the various species of Lemurs. They are mainly arboreal, housed in the Mammal House and their diet is similar to that of the monkeys.

Only small numbers are kept in the collection at any one time.

Period 1938-49

The three Lemurs (Lemur ?) dying during this period were reported as:-

1. Pneumonia of the left lung.
2. Enteritis and peritonitis. Bacteriological examination negative. Death considered due to toxæmia.
3. Parasitic cysts in lung and liver, not further described.

Period 1951-52

P51/10, an old male Ring-tailed Lemur (*Lemur catta*) was the only death during this period. Little was seen on post-mortem examination excepting a degree of fatty change in liver and kidneys. This animal was almost certainly senile.

FAMILY LORISIDAE and FAMILY GALAGIDAE

The former includes the Lorises and Pottoes, the latter the Galagos and or Bush-babies.

Only small numbers are kept and they are housed in heated cages in the Reptile House, completely screened from the public by glass.

Their diet is mainly tomatoes, bananas, grapes and other fruits and mealworms.

Period 1938-49

The only three reports are of

1. Bosman's Potto (*Perodicticus potto*) with acute peritonitis.
2. A Galago affected with pneumonia.
3. A Galago which was decomposed when received and partially digested by blowfly maggots.

Period 1950-51

The five deaths during the period were:-

P51/8. An old Demidoff's Galago (*Galago demidoffii*) which was in thin condition. The principal finding on post-mortem examination was an infestation with parasites resembling half-grown 'blowfly' larvae. These were found free in the thoracic and abdominal cavities, embedded in the lung and liver tissue, attached to the peritoneum, and within the stomach attached to the mucosa.

P51/12. An old Slender Loris (*Loris tardigradus*) in which a similar infestation was discovered. Histological examination showed the parasites in the tissues to be surrounded by a zone of reaction, and the parasites were tentatively identified as larval forms of a Linguatulid.

P50/2. Another old Slender Loris was not received for post-mortem examination. Previous to death it had shown an indolent ulcerative condition of the skin of one hind foot which was very resistant to treatment.

P50/7. Another Demidoff's Galago showed severe injuries on post-mortem examination, presumably inflicted by its cage mates.

P51/9. A very old Bosman's Potto. Post-mortem findings were inconclusive, but the animal may have been senile.

CLINICAL NOTES

Injuries

These frequently occur among the primates, mostly in those cages where a number are kept together. Minor bites and scratches have been found to heal readily, rarely becoming infected. Even many large wounds healed satisfactorily without treatment in a very short time, though in two cases the animals were caught up and the wounds dressed and sutured. One was a severe brow wound in a Mangabey, the other an axillary wound in a Tantalus Monkey (*Cercopithecus tantalus*). In the latter case no attempt was made to use the arm for three weeks after which full use rapidly returned.

A number of suspected bone injuries have disappeared during isolation and without treatment, but in two cases splinting was necessary. One was a fracture of a caudal vertebra in the long tail of a Diana Monkey (*Cercopithecus Diana*) which did not heal until a light alloy cylinder held in position with adhesive plaster was used to immobilise it. The second was a high femoral fracture in a baboon. Plaster of Paris bandage^s was used in conjunction with a metal rod extending in an arc over the loins and well padded. Recovery was uneventful.

A suspected nerve injury was seen in a young baboon which carried its right arm in a similar position^{to}/that associated with radial paralysis. It seemed probable that the arm had been overstretched by another monkey seizing the first while suspended from the roof. Full use returned after about

ten days.

Diarrhoea

This is a common occurrence among apes and monkeys after busy visiting days when unsuitable food has been given by the public. In the chimpanzees, however, protracted diarrhoea sometimes occurs from no obvious cause. Simple dosage with kaolin in the food or an intestinal sedative mixture containing opium are commonly successful remedies. On other occasions large doses of sulphaguanidine (May & Baker) have been required. This sulphonamide is preferred to phthallyl-sulphathiazole as it is less bitter. Bacteriological examination of the faeces has not usually disclosed a pathogen, but on one occasion an unidentified *Shigella*-like organism was recovered from the faeces of a Chimpanzee. Another possible cause may be the consumption of leaves which blow into the outdoor cages. Only cursory examinations have been made for the protozoan parasites.

"Colds"

The Chimpanzee appears to be very susceptible to the human type of "common cold" and undoubtedly the specimens at Edinburgh contract the infection from the keepers and from one another. In addition, it appears that the infection can be contracted in reverse, when, in the keeper's opinion the 'cold' seems to be unusually severe. In the majority of cases recovery occurs without complication, but in young chimpanzees there may be severe sequelae (e.g. case P50/10).

Orang-outans appear to be slightly less susceptible although they are affected. The monkeys appear to be immune. Hamerton (1939) refers to the infection in Gibbons as well as in Chimpanzees (1942) at London, and Goss (1942) also mentions

'colds' in Primates at the Bronx menagerie.

"So-called Green Monkey Disease"

This term is applied by lay staff to a condition which has most frequently been seen in Green Monkeys, though similar symptoms do occur in other members of the Cercopithecidae. The animal suddenly becomes prostrate with partial or complete posterior paralysis. The temperature is very low per rectum, there are convulsive graspings with the hands, periods of semi-coma and some hyperaesthesia when disturbed. Death occurs in one to four days and post-mortem examination is inconclusive. The writer has seen several cases of this nature, but has also seen similar symptoms in monkeys dying from definite causes. The possibility of unrecognised nervous and other disease is discussed below.

The case history of a Green Monkey is given here because it is the only one in which recovery has been seen by the writer.

4/1/50. Prostration, inappetance, grasping movements with hands.

No hyperaesthesia. Placed in heated atmosphere.

6/1/50. Partial coma. Temperature low. Laboured pulse.

Drinking a little water. 2 i.u. Insulin injected.

7/1/50. Much improved. Appetite returned. Rectal temperature 95.5°. Diarrhoea.

8/1/50. Shivering. Otherwise normal.

11/1/50. Normal. Discharged.

This animal is in perfect health and has had no recurrence of the condition two years and six months later.

'Convulsions'

Short sporadic bouts, resembling epileptiform 'fits', not uncommonly affect monkeys of the Cercopithecidae, although

frothing at the mouth has not usually occurred. Their etiology is obscure.

Parasitism

Thirty-eight reports on faecal examinations carried out during both periods give the following findings.

Strongyloides eggs	16 times
Strongyle spp. eggs	9 times
Trichuris eggs	7 times
Enterobius eggs	7 times
Ascaris eggs	3 times
'Hookworm' eggs	2 times
Negative for parasites	11 times

A number of these reports are from the same animal at different times and the majority are from Chimpanzees.

Faecal sampling in this, as in other orders, has been desultory and these figures are, of course, too small to be significant except possibly as an indication.

One case worth mentioning in some detail is that of 'Charlotte', a young Orang-outan. On arrival in 1950 she was listless, though in reasonable condition. After some weeks all appetite was lost and a faecal examination revealed:-

1050 Strongyloides e.p.g.

28,500 Ascaris e.p.g.

50 Strongyle e.p.g.

Numerous Trichuris eggs

in a sample taken after a period of constipation. In another sample a few days later the count was 100 Strongyloides and 3,380 Ascaris e.p.g.

The animal was so weak that it was considered inadvisable to give vermifuges at once and since no food would be taken, milk fortified with glucose and Casilan whole

protein was given. Injections of vitamin B₁₂ were given and an X-ray examination revealed no foreign body or other positive finding. When the animal began to feed again, she was dosed with small amounts of santonin and phenolphthalein and a small number of ascarids were passed on several occasions. There followed a complete and uneventful recovery and she has remained healthy to the present time (1952).

'Grumpy', another young Orang outan, partner of the above, developed diarrhoea with innappetance at a much later date. Faecal examination revealed a heavy *Enterobius* affection. Dosage with "Dipheman" (British Drug House) was followed by a speedy recovery, but it has not been possible to re-examine the faeces since treatment was begun.

Tail Chewing

During the winter of 1949-1950, and apparently on many previous occasions, self-mutilation of the tail became frequent among the Cercopithecidae. No cause was found, nor remedy discovered. The monkeys grasped their own and each other's tails and consumed them as they would a banana. Amputation did not prove worth while and the wound was persistently interfered with. One case is reported by Hamerton at London in 1937.

This problem did not recur in the 1950-51 winter, by which time new heating plant had been installed, and it is considered that the cause may have been an inadequacy of caudal circulation, although it is improbable that the temperature became low enough to permit frost bite to occur.

Loss of Hair

Loss of tail hair occurred in the Ring-tailed Lemurs and both Common and Black-tailed Marmosets. The cause was obscure but may have been connected with inadequate circulation. Ultra violet irradiation was persisted in without success, though

application of 'Tetmosol' (I.C.I.) appeared to assist regrowth in the Lemurs.

Overgrowth of Nails

A chloroform spray was used to anaesthetise an adult Baboon for nail clipping.

Phimosis

A young Mangabey suffered from this condition, which disappeared after a few days without treatment. It was probably the result of an injury.

DISCUSSION - THE PRIMATES

The differences between the various orders of mammals are discussed at the end of Section A and tables and histograms are given there. It is necessary here to discuss only those points arising from a study of this order alone.

a) As stated elsewhere, no analysis of the deaths occurring during the period 1938-49 can be made on the basis of length of time spent in the gardens. The total dying during the period 1950-51 is a very small number on which to base any conclusion, but it is interesting to note that only 5 of the 24 primates dying had been in the park less than six months. This may be connected with the infrequency of tuberculosis or may indicate that the primates are inherently suited to captivity.

b) The small number of cases of tuberculosis, especially during the second period studied, is most remarkable. The glass screens which protect the apes from intimate contact with the public may well account for the infrequency of the disease among them, but the Monkeys have no such protection. No form of tuberculin testing or lengthy quarantine have been employed (see appendix referring to 1952), and the incidence of the disease among the public in this city does not presumably differ greatly from that elsewhere. That the incidence of the disease is indeed high in other zoological collections can be seen from the Annual Reports of other Zoological Societies (Hamerton, Rewell, Fox, Ratcliffe, etc.), and from the writings of Schroeder, Goss and many others. Ratcliffe (1951) has studied the relationship of diet to tuberculosis at the Philadelphia garden and his work indicates that a correctly

balanced diet rather than one adequate of even excessive in quantity can play an important part in reducing the incidence of this disease. Doubtless the excellent and varied diet, supplemented by vitamins and minerals, which the Primates receive at Edinburgh is partly responsible for their resistance to infection, but it is improbable that this alone would account for its infrequency. Schroeder (1938a) considers that probably 80 per cent of the Primates which die of tuberculosis in America have become infected before arrival in that country, either in dealers' yards or during transport, and this may well apply to the Primates reaching Britain. The majority of those in the Edinburgh collection, however, are obtained not from dealers but as gifts from friends of the Society abroad and from individuals who have kept the animals as pets until they became intractable. It seems probable to the writer that this is the fundamental reason for the Society's fortunate position regarding Primate tuberculosis.

c) The small number of cases of neoplastic disease.

Ratcliffe () reports a similar infrequency at Philadelphia, but quotes Zuckerman's belief that this is related to the short length of life of captive Primates. Many of the Apes and Monkeys, however, live to a considerable age at Edinburgh and also at London, where the incidence of neoplasia in Primates seems to be similarly low judging from the infrequent mention of the condition in the annual reports of Hamerton, Rewell and Osman-Hill.

It is interesting to note that two of the three cases at Edinburgh were carcinomata involving the pancreas, in view of the cases published by Ratcliffe (1930, 1932a) which included adenocarcinoma of the pancreas in a Grivet Monkey and a Baboon.

Since several cases of an inflammatory nature affecting the pancreas have been seen in Primates at Edinburgh, it may be that this organ is particularly susceptible to disease processes in this order. Osman Hill (1951) also refers to diabetes in a King Colobus Monkey and a Bush Baby, at London.

d) Although only three reports on Primates show the principal post-mortem abnormalities to be of the nervous system, it is probable that the incidence of nervous disease is actually higher than this would indicate. The condition referred to as "Green Monkey Disease" is mentioned under the section devoted to clinical work. As stated, it is doubtful if this is a real entity, as similar symptoms, i.e., sudden prostration, hyperaesthesia, partial opisthotonus, etc., have been seen in Monkeys dying from non-nervous disease recognisable on post-mortem examination. The comparatively frequent occurrence of these symptoms, followed by death and an inconclusive post-mortem examination, does however raise the question of nervous disease. Hamerton (1936) (1941, 1942) and Hamerton and Rewell (1947) describe a sub-acute demyelination of the spinal cord and the occurrence of 'fits' in Stair's and Green Monkeys on several occasions and Corson-White (Fox 1927) spinal degeneration in Drill. It is possible that had a careful histological examination of the spinal cords of the monkeys dying at Edinburgh been carried out, a similar demyelinating condition would have been discovered. Goss (1942) describes an infectious encephalitis among monkeys at the Bronx zoological gardens in which one of the principal symptoms is blindness which may be permanent. Nothing similar to this has been seen at Edinburgh, but he also refers to the frequency of tetanus (*Clostridium tetani*) infection among small monkeys, the symptoms of which are not dissimilar from some of those seen by

the writer. Attempts have been made to recover the tetanus organism from wounds in dead monkeys and on one occasion tetanus anti-toxin was employed. Both these endeavours were unsuccessful but this does not remove the possibility that the disease may sometimes occur here and be undiagnosed.

During the latter half of 1951 and the first eight months of 1952 the writer has seen very few 'fits' occurring in the monkeys, and the number of deaths from undemonstrable cause has been very few. This period coincides roughly with that during which whole-wheat bread has been used for feeding and it appeared possible to the writer that possibly a deficiency of the vitamin B complex had existed. Hamerton remarks in his report for 1945 on the reduced frequency of sub-acute demyelination in monkeys at London during the war years and presumably the monkeys during this period would have been receiving bread made from 'National' flour. The question of 'Agerisation' of flour responsible for some cases of canine hysteria (vide Mellanby 1946) also arises. As mentioned in the clinical section, the habit of tail-biting has also disappeared, but this occurred prior to the change in bread and seems more probably due to temperature factors as stated.

e) A high incidence of bone disease in the Cebidae and Hapalidae is also reported at London by Hamerton (1939) who, referred to the prevalence of bone diseases "among Platyrrhine primates which do not respond to ordinary rachitis treatment." An annual discussion of these diseases is given by Fox and Ratcliffe in the reports of the Philadelphia Society, but they found the incidence to be equally high among the macaques (Fox 1931). This was however before the mechanism of calcium metabolism and the importance of vitamin D was understood. They also refer to the development of Paget's Disease or

osteitis deformans in monkeys when calcium intake is increased in an attempt to cure rachitic conditions in monkeys. At Edinburgh little difficulty has been found in successfully treating Old World Monkeys, described but in the case of the two Woolly Monkeys described there would appear to be another factor involved. Both these monkeys habitually passed moist semi-solid faeces and carried a strongyloid infestation. They were not treated with anthelmintic and it may be that bowel absorption of minerals was to some degree hampered by the rapid passage of bowel contents, or by the presence of the parasites. There is a remarkable similarity between the photograph appended and that given by Fox (1923).

(1950)

Rewell, commenting on the frequency of rickets in marmosets in the London zoological collection, ascribes it to the poor conditions under which the animals are kept before shipment. Lucas et al. (1927 and 1937) recount the use of ultra-violet irradiation in preventing the occurrence of rickets in Marmosets. They describe one of the few successful attempts to breed these animals in Britain, which terminated in the second generation apparently because of hyperfecundity, possibly associated with the irradiation.

f) The small number of cases in which parasites have been found is a true estimate only of the larger parasites. Strongyloides infestation is undoubtedly very common, the eggs of this nematode having been found in almost every Primate faecal sample submitted for diagnosis during the period 1950-51. That the infestation can be pathogenic can be seen from the small epidemic among Gibbons reported at Vincennes Zoological Park in Paris by Urbain et Nouvel (1950).

Linguatulid parasites have been reported at London by

Hamerton (1942) in the lungs of a Brown Lemur and in the lungs of snakes by Hamerton (1941) and by Fox (1936) at Philadelphia. Fly larvae in the peritoneum of a Gibbon are reported by Fox (1931) and it seems possible that these, like the fly larvae reported at Edinburgh in the Galago, were also linguatulids.

No protozoal infestations of the alimentary tract have been discovered at Edinburgh, although these appear to occur in other zoological collections as reported by Fox (1931) at Philadelphia and by Hamerton (1942) at London, etc. Pulmonary acariasis which has been so common at London has not been seen (Hamerton 1938, Rewell 1948e).

g) There are many reports of Salmonella and Shigella infections in Primates in the literature. *B. flexneri* is reported by Osman Hill (1952) in a Rhesus Monkey and by Rewell (1948), who also mentions the infection of two keepers by *Shigella Schmitzii* contracted from a Gibbon. Rewell (1948e) also discusses the varying actions of bacteria of these groups in man and animals.

ORDER LIPOTYPHILA

This order includes the Hedgehogs. Small numbers have been kept in the past, but only three reports of post-mortem examination were available for study. All three were dated August 1946 and concern the Common British Hedgehog (*Erinaceus europaeus*). One refers to 'bilateral septic pneumonia,' one to 'post-parturient septicaemia' and one merely to 'inanition.'

No hedgehogs were kept during the period 1950-51.

ORDER CHIROPTERA

This order includes all the Bats. None were apparently submitted for post-mortem examination during the period 1938-49.

One Long-eared Bat (*Plecotus auritus*) died a few days after arrival in 1950 during the writer's absence. No post-mortem examination was carried out, but the cause of death was very probably inanition due to refusal to feed.

ORDER CARNIVORA (CARNIVORA FISSIPEDIA)

This order includes all the land carnivores, and is here considered as a whole. The anatomical differences between species of the various families is much less than in the Primates, and no one family contains the majority of the animals ^{did} considered as the Cercopithecidae in that order.

The number of deaths during the two periods in the different families is as follows:-

	1938-49	1950-51	Total
Felidae. Lion, Tiger, Leopard, Ocelot, Cheetah, etc.	68	6	74
Viverridae. Civets, Genets, Mongoose, etc.	19	4	23
Hyaenidae. Hyaenas	5	-	5
Protelidae. Aard-Wolf	-	1	1
Canidae. Wolf, Foxes, Jackals, Coyote, Dhole, etc.	50	5	5
Mustelidae. Badgers, Otters, Ferret, Stoat, Weasel, etc.	28	7	35
Procyonidae. Raccoon, Coati Kinkajou, etc.	14	-	14
Ursidae. Bears	6	1	7

The diet of the felines, canines and hyaenas is solely meat. This is provided by horses slaughtered in the park's own abattoir and because of the shortage of horses, it is at present being supplemented with whale meat. Offal is not usually fed to the mammals, although the horse liver is used on occasion as a laxative. The viverrids and procyonids receive meat and fruit and the mustelids mostly meat, although the otters are fed on fish. The Bears are fed largely on bread, maize and vegetable foods, but the Polar Bears receive horse meat and fat.

The civets and some of the smaller cats are housed in

the Small Mammal House and are permanently in a warm atmosphere. The Tigers, Cheetahs and Coatis have a heated indoor house attached to their outdoor enclosures and all the remaining animals have no heat throughout the year.

Period 1938-49

A total of 190 reports are available for study concerning animals of this order.

The Cardiovascular System

The three reports included here are of endocarditis in a Polar Bear (*Thalarctos maritimus*) and a Tiger (*Felis tigris*) in which no estimate of the animals' ages are given, and of venous haemorrhage of unstated origin in an Arctic Fox (*Alopex lagopus*).

Embolism of the heart with a worm of the genus *Dirofilaria* is included under 'Parasitic Disease.'

The Respiratory System

Excluding two cases of tuberculous pneumonia which are considered under the heading of Tuberculosis, the 28 reports in which abnormality of this system was the principal finding concern:- 3 Adult Lions and 2 Lion cubs (*Felis leo*), 4 Mongooses (*Herpestes* ?), 4 Raccoons (*Procyon lotor*), 3 Ferrets (*Futorius furo*), 1 Red Fox (*Vulpes vulpes*), 2 European Badgers (*Meles meles*), 1 Genet (*Genetta* ?), 1 Civet (*Nandinia* ?), 1 Otter (*Lutra lutra*), 1 Wolf cub (*Canis lupus*), 1 Coati (*Nasua* ?), 1 Tibetan Mastiff (*Canis familiaris*), 1 Kinkajou (*Potos flavus*), 1 Fishing Cat (*Felis viverrina*) and 1 Himalayan Bear (*Ursus tibetanus*).

Divided according to families thus:- Felidae 6, Viverridae 6, Canidae 3, Mustelidae 6, Procyonidae 6, and Ursidae 1, - no significant variation is seen.

In only two of the reports is mention made of bacteriological examination, beta-haemolytic streptococci being recovered from the pneumonic lungs of the Fishing Cat, and

necrophorus from the thoracic cavity of a Common Fox.

In the reports on two Raccoons, canine distemper infection was suspected but not confirmed.

Regarding the actual descriptive terms used in the reports, bronchitis and various forms of pneumonia are mentioned in 17, the remainder being rather more vague descriptions such as consolidation, patchy fibrosis, etc. In four of the reports included, 'congestion of the lungs' was the sole or principal finding.

A further eight reports mention respiratory abnormalities among other more important findings.

The Alimentary System

Fifty-three reports are included under this heading which excludes five reports of alimentary disease due to parasites, three due to special infections, two of neoplasia, and two secondary to other factors.

These 53 reports are considered under the following sub-headings.

The Oesophagus

An obstruction of the oesophagus in a Wild Cat kitten (*Felis sylvestris*) with a fish bone is described.

The Stomach

Two obstructions occurred in a Hyaena (*Hyaena* ?) and an Otter.

Gastric ulcers are reported in a Kinkajou and a Mongoose. They are also referred to in a report on a Raccoon included under Neoplasia.

Gastritis is reported in a Hyaena, a Tiger where it was associated with colitis, and in a Lioness with enteritis and anaemia.

Gastric haemorrhages are reported in a Wild Cat kitten also infested with round worms, and haemorrhagic gastro-enteritis occurred in a ferret.

Torsion of the stomach was the sole finding in a Lion.

The Intestines

Obstruction is reported once in a Raccoon like Dog (*Nyctereutes procyonoides*) and impaction five times in a Manx Cat (*Felis catus*), a Scottish Wild Cat and two hybrid kittens and a Civet Cat (*Civettictis civetta*?).

Apart from two reports which also mention jaundice and are included under the section concerning liver abnormalities, 'enteritis' forms the sole or principal finding in 16 reports which concern 3 Wild Cats and 1 Wild Cat kitten, 2 Ferrets, 1 Lion and 2 Lion cubs, 2 Tiger cubs, 1 Badger, 1 Civet, 1 Mongoose, 1 Himalayan Bear and 1 Siamese Cat.

The cause of the intestinal inflammation is not stated. In the case of the two Tiger cubs, dermatitis was also reported.

Intussusception is reported in a Wolf as sole finding, in a Cheetah (*Acinonyx jubata*) which also showed prolapse of the rectum and a bilateral pneumonia, and in a Fox which showed jaundice of the viscera.

Rectal prolapse is also reported in a rachitic Wild Cat kitten.

Intestinal perforation of undescribed origin is reported in a Striped Hyaena (*Hyaena hyaena*).

Multiple intestinal abscesses were reported in an Indian Mongoose (*Herpestes nyula*).

The Pancreas

Haemorrhagic pancreatitis is reported in an Ocelot (*Felis pardalis*) and this is the only mention of pancreatic abnormality excluding neoplastic conditions.

The Liver

Five reports mention hepatic abnormalities; 'cirrhosis' in a Brown Bear (*Ursus arctos*) and a Lion, caseating hepatitis in a Ferret, hepatic necrosis in a Badger and hepatic 'degeneration' in an Otter.

Four other reports describe 'jaundice' in a Silver Fox (*Vulpes fulva*) and a Puma (*Felis concolor*) with enteritis; an Arctic Fox with 'cystic goitre' and a Badger.

An hepatic carcinoma in a Brown Bear has been included under that heading.

Others

The remaining four reports included under the Alimentary System describe intra-peritoneal haemorrhage of unstated origin in two Wolf Cubs, stomatitis and dental abnormalities in a Red Fox and an anal abscess in a Tibetan Mastiff.

The Urinary System

In 13 reports abnormalities of this system form the principal finding, and in 8 others nephritis is found associated with more important findings. One of the 13 reports is of a neoplastic condition and is dealt with under that heading. Of the remaining 72 reports, eight concern nephritis, twice described as 'chronic' in a Raccoon and a Husky Dog (*Canis familiaris*) and once as tubular in a Silver Fox. The other five reports of nephritis do not describe the condition further, and in each case it is associated with other findings,

the animals affected being a Raccoon-like Dog, two Wild Cats, a Tiger and a Raccoon.

The other four reports describe toxæmia from a kidney abscess in a Ferret, 'fibrosis' of kidney and lungs in a Palm Civet, 'sand' in the urethra in a Wolf, and obstruction of the urine flow in a Mongoose.

The Reproductive System

The four reports included here relate to female animals. There is no record of any abnormality in the male genital system. One is of an acute mastitis in a Dingo (*Canis familiaris*), one of peritonitis subsequent to dystokia in a Lioness, one of post-partum endometritis in an Indian Mongoose and one described as "endometritis or peritonitis" in a Leopard (*Felis pardus*).

The ~~Saxtux~~ Nervous System

No report describes nervous disease as the principal post-mortem finding and the only report which deserves mention under this heading is that of a Wild Cat kitten included under the Alimentary System because of the principal finding, a fish-bone in the oesophagus. In addition mention in the report is made of a "sub -dural hæmorrhage."

Other Tissues

Anaemia was the sole finding reported in one Mongoose, although it was associated with more important findings in five other reports.

Lymphatic leukaemia is reported in a Leopard and is included under this heading, although it might perhaps be equally well classified under Neoplastic Disease.

Two other reports, of "post-operative changes" in a Cheetah and of "congenital abnormalities" in a Red Fox cub are also classified here.

Dietary Deficiencies affecting the Skeleton

In 9 reports this type of bone disease formed the principal finding. The term 'rickets' is used to describe it in 2 Silver Fox cubs, 1 kitten, 1 Wolf cub and in 3 Red Foxes in one of which it was associated with severe anaemia. For a Wild Cat, also with anaemia, the term osteomalacia is used and for an undernourished Pale Fox (*Vulpes pallida*) it is described as osteoporosis.

"Skeletal abnormalities" and "disturbed calcium metabolism" are phrases used in six other reports where death was ascribed to other causes.

A report of osteoporosis is associated with a parathyroid adenoma ^S included under 'Neoplasia.'

Other Dietary Diseases

In 13 of the reports included here the findings are ascribed to cachexia, inanition, malnutrition, etc. In one, a Red Fox, obesity is the only abnormality referred to.

In two other reports the sole findings were abnormality of the thyroid gland. This is described as 'cystic goitre' in a Desert Fox (*Vulpes levespus*) and 'exophthalmic goitre' in a Leopard. Seven other reports concerning 3 Foxes, a Wolf cub, a Dingo, a Civet and a Raccoon also referred to thyroid abnormalities, but these all showed other findings of more importance.

Parasitic Disease

In 11 reports only does parasitic infestation appear as the principal finding, seven of which concern poorly developed Wild Cat kittens carrying a heavy 'roundworm' infestation. The others were malnutrition due to 'tapeworms' in a Fennee^c Fox (*Vulpes zerda*) and two reports on Golden Cats (*Felis temminckii*), one showing gastro-enteritis presumed due to

'roundworms' and one a worm of the genus *Dirofilaria* within the heart. One Red Fox was affected with sarcoptic mange.

In a further 12 reports parasites are recorded in a secondary role. Those worthy of further mention concern an infestation with 'pentastome' flukes in a Mongoose, and widespread *Trichinella spiralis* cysts scattered throughout the diaphragmatic and intercostal muscles of a Polar Bear.

Neoplasia

All cases of neoplasia occurring have been considered as principal findings and the items reported are listed below in families. Other findings are included in parenthesis.

Felidae: None

Viverridae: Palm Civet. "Neoplasia or endometritis"

Palm Civet. "Alveolar Carcinomata" (Hydrothorax)

Canidae: Wolf. "Lymphosarcoma"

Dhole. "Pancreatic carcinoma" (*Cuon dukhunensis*)

Indian Wild Dog. "Multiple carcinomata"

Silver Fox. "Adenoma of parathyroid (Osteoporosis)"

Procyonidae: Raccoon. "Pancreatic adenoma" (Gastric ulcers)

Raccoon. "Fibrosarcomata" (Thyroiditis)

Raccoon. "Neoplasia of kidney"

Ursidae: Brown Bear. "Hepatic Carcinoma" (Helminthiasis)

Special Infections

Tuberculosis: Only four reports mention this disease. The findings are given thus:

Dingo "Some tuberculosis" (Goitre)

Lion. "Tuberculosis"

Badger "Tuberculous bronchopneumonia"

Raccoon "Tuberculous bronchopneumonia (Cholelithiasis)"

Special Diseases

The 11 reports included here refer to:-

"Pyæmia" in a Tigress and a Puma with hæmolytic streptococci.

"Septicæmia" in a Skunk (Mephitis ?) and in a Dingo. The organism is not stated in the former, but was *Bacillus morgani* in the latter.

"Chronic polyarthritis" in two young Lions.

"Feline enteritis" in two kittens.

"Toxaemia" arising from subcutaneous abscesses in a Raccoon.

"Suspected leptospiral Infection" in a Red Fox showing jaundice.

"Actinomycosis" in an Otter.

Several other reports mention jaundice as a symptom and especially in the case of a Badger which died in the same month as the Red Fox above; it is quite possible that leptospiral infection was concerned in these also.

Canine distemper was suspected in the report on a Raccoon included under the Respiratory Disease heading, and this also appears to have been a possibility in another Raccoon and a Ferret.

Violence

One of the reports concerns a young animal, a Badger dying at birth although it is certain that many more such new born animals must have been killed which presumably were not submitted for examination.

The remaining nine reports concern 7 Foxes of different species, a Tiger cub and a Leopard. In two of these cases the cause of death was toxaemia from gangrenous wounds.

Inconclusive

15 reports found insufficient abnormality for diagnosis to be made.

Period 1950-51

Twenty-four members of the Order Carnivora were examined post-mortem during this period.

The Respiratory System

Five cases are included under this heading:-

C51/11 Lion "Ike", nine-year old male, bred in the park.

This animal died during the last of several respiratory 'spasms' without other premonitory symptoms. The principal findings on post-mortem examination were pulmonary oedema, areas of bronchitis and enlargement of the thyroid gland. Decomposition rendered bacteriological examination unreliable.

C51/6 A newly arrived Stoat (*Mustela erminea*) showed only marginal congestion of the lungs on examination.

Death may be considered due to "chilling", the animal's cage being in an exposed situation. Stoats are known to be poor subjects for captivity and their small size will render them sensitive to sudden temperature changes.

C50/1 A Weasel (*Mustela nivalis*), four months in the park, also showed only pulmonary congestion. The remarks concerning the Stoat also apply here.

C51/9 A young, newly-arrived Otter. This animal was still being bottle fed. The principal finding was broncho-pneumonia from which only *Proteus vulgaris* and coliform organisms were recovered. There appeared to be several small ulcers in the gastric mucosa, presumably dietary in origin.

C50/10 An Aard Wolf (*Proteles cristatus*). This animal forms the sole species of the family Protelidae and is rarely seen in captivity, though there is reference to one that

lived for ten years in Philadelphia Zoological Park (Fox, 1941). The natural diet of this animal is termites, which are impossible to supply in captivity and Edinburgh's young specimen had been living on eggs and milk and would take no other food. The animal's faeces were consistently soft. A few weeks after arrival it was found comatose and recovered in 15 minutes after glucose-saline injections. Severe anaemia was treated with injections of vitamin B₂ and vitamin B₁ was also given in addition to vitamin D and calcium di-phosphate supplements in the milk. The animal developed a fractious appetite and was offered all types of animal, insect and vegetable food. It would eat none of these except on two occasions when it consumed some horse fat, reputedly similar in constitution to termites, and some baked custard. The comatose state recurred and became increasingly frequent and of longer duration until death occurred three weeks after the inception of the illness. On one occasion the animal partially recovered from the coma and circled the cage actively for a long period apparently oblivious of its surroundings.

Post-mortem examination revealed only an acute suppurative bronchitis from which no pathogenic organisms were recovered and which was presumably terminal. Examination of the brain failed to show any abnormality.

Parasitic bronchitis in a Pine Marten and a Crab-eating Fox must also be mentioned here, though considered under the heading of Parasitic Disease.



Alimentary System

- C51/7 A male Common Fox, in the park for many years, was destroyed. It had many loose teeth, foul breath and showed other signs of old age. Histological examination of the tissues post-mortem revealed little excepting fatty change in hepatic cells and renal tubular epithelium. Bacteriological examination was negative.
- C51/12 Leopard Cat (*Felis bengalensis*) in the park for one year. This animal took no apparent exercise whatsoever, although it may have moved about at night. Death occurred with no symptoms and examination revealed some pulmonary and intestinal congestion and a considerable increase of fibrous tissue surrounding the hepatic bile ducts. Bacteriological examination was negative.
- C51/13 Hybrid Wild Cat kitten in the park for about four months. Appeared normal one evening, was heard "calling." the following morning when it was found to have a subnormal temperature and to be semi-comatose. It died thirty minutes later despite stimulant injections and on examination the only abnormalities seen were thickening of the intestinal mucosa and an angular appearance of renal glomerulae, possibly an artefact. Infectious Feline Enteritis was suspected as this animal was caged in a position where domestic cats are known to prowl at night.
- C50/6 An Otter, newly arrived, died from impaction of the large intestine with sand. The pica initiating this was possibly due to 'indigestion' caused by unsuitable food given by the public.

Mention must also be made here of three cases of impaction of the large intestine in two Chinese Civets and a Leopard due to skeletal abnormality.

Dietary Deficiencies affecting the Skeleton

All four of the animals included under this heading showed signs of bone disease when they arrived in the park.

C50/14 and C/51/2. A pair of adult Chinese Masked Palm Civets

(*Paradoxurus larvatus*) showed distension of the abdomen, and distorted long bones. This rachitic condition did not respond to treatment with vitamin D and calcium diphosphate and after death a similar picture was seen on post-mortem examination in both cases. The principal abnormality was gross distension of the terminal colon with food material, the impaction apparently originating because of the reduced size of the pelvic canal and an atonic condition of the intestinal musculature. Bacteriological examination of the bone marrow was negative in both cases.

C50/17. A young Leopard showed similar symptoms and died 14 days after arrival from a similar cause. The colon was impacted with food material and had presumably obstructed urine flow within the cramped and rachitic pelvis and so caused the rupture of the bladder which killed the animal.

C51/1 A Black-backed Jackal (*Canis mesomelas*) had been treated for rachitis since its arrival six months previously. Post-mortem findings were inconclusive and the long bones, though distorted, were firm and hard.

Other Dietary Diseases

The only case included here is C51/3, a Ferret, which

had been in the park for some time and died after being deprived of food for 24 hours by mismanagement. Post-mortem findings were inconclusive.

Parasitic Disease

in
The only animal/which death was ascribed to parasitic infestation was a Pine Marten (*Martes martes*), C51/5, showing verminous bronchitis and splenic haemangioma. It had lived in the park for eleven months.

A heavy infestation of *Trichinella Spiralis* was seen in the diaphragm and intercostal muscles of the Polar Bear, C51/8, and a single worm, presumed to be a species of *Dirofilaria*, was found in the heart of a Crab-eating Fox C51/3, which also showed a verminous infestation of the lungs. Both these animals died from violence.

Violence

Seven animals are included here which either died as a result of injury or were destroyed because of injury.

C50/4 a new-born Badger and C50/18 a new-born Palm Civet were killed by the adults shortly after birth.

C51/3 a newly arrived Crab-eating Fox (*Cerdocyon thous*) showing parasitic infestation as described above, also died suddenly showing intense hepatic congestion and apparent rupture presumed due to violence.

The remaining four animals were old stock.

C50/8, a Silver Fox, and C51/4, a Wolf, were destroyed after being severely injured by their companions.

C50/7, a Lioness 'Lena', was destroyed when prolapse of bowel occurred through an operation wound after a successful hysterectomy carried out by the clinical staff of the Royal (Dick) Veterinary College. The operation was made necessary by the retention within the uterus of three dead cubs, and was

carried out under 'Pentothal' and ether anaesthesia.

C51/8, a Polar Bear 'Wendy' was about 27 years of age. The animal showed recurrent lameness in the left hind leg for a long period. Treatment was not possible until it became prostrate, when it was ineffective. Necrosis and gangrene of all the tissues of the hind leg was found extending up to the level of the hock and arising from an infected wound in the pad, presumably caused by broken bottle glass thrown into the bear's pool by visitors. In addition the kidneys showed chronic interstitial nephritis, and infestation with *Trichinella spiralis* referred to above, and a large osteophytic outgrowth of the vertebral column, fusing together several of the cervical vertebrae.

Inconclusive, etc.

C50/13. An old Lioness 'April' was destroyed during my absence. Post-mortem decomposition rendered examination impossible, but the animal may have been senile.

C50/19. A newly arrived Ferret showed no abnormalities when examined post-mortem.

CLINICAL NOTES

Injuries

Very few injuries have occurred among the carnivores excluding the killing of young at birth which has occurred to my definite knowledge in Arctic Foxes, Leopards, Lions, Badgers and Civets, and by repute in many other species. The cause is almost certainly the inability to provide separate accommodation for the pregnant female near, during and after parturition. As stated above, injuries inflicted on an adult Wolf^{and Fox} were severe enough to make destruction necessary. One Silver Fox was the only carnivore to require clinical treatment. This was for severe laceration of the face and mouth, which cleaned and dressed and healed rapidly with no further treatment.

Bone Diseases

Several young carnivores showed enlargement of the epiphyses of the long bones and other symptoms of rachitis on arriving from abroad, especially species of the larger felidae. The cause of this is probably that the mother is shot while the cubs are still suckling and they are weaned too early on to an inadequate or ill-balanced diet. Rachitis does not seem so common in the smaller species, i.e., Leopard, Cats, Civets, etc. possibly because the quantity of milk they are reared on is much greater relative to their size.

A proprietary, water-soluble vitamin concentrate, 'Abidec' (Parke Davis & Co.) is used in the park for maintenance vitamin dosage, but the concentration of vitamin D in this product is inadequate for treatment purposes even when given in large doses. 'Super D Oil' (Crookes), which has a potency of 2000 i.u. vitamin D and 1,600 i.u. vitamin A per drop, has been found the most suitable supplement, a very small quantity

only being necessary and hence it is readily taken by most animals. A mineral supplement containing bone meal is added as a routine to most diets, but in cases of suspected deficiency calcium diphosphate has been given in addition.

In the majority of cases the condition has not been far advanced and 2-3 drops of the oil and one teaspoonful of calcium diphosphate per head daily have been sufficient for Leopard, Lion and Wolf cubs, etc. One young Cheetah, about half-grown, developed enlarged epiphyses and became lame in one hind leg after arrival. Other treatment including ultra violet irradiation was used without success, but complete recovery occurred in six weeks when the treatment outlined was employed. One young Black-backed Jackal, which arrived showing severe malformation of the forelegs did not respond after protracted dosage and died uncured from other causes.

The practice has recently been employed of sending supplies of the supplement mentioned to intending exporters of valuable animals, with instructions for their administration. Two half-grown Tiger cubs were received in 1951 in excellent condition and it is felt that this scheme had been of value.

Tail Biting

Two young adult Leopards began biting the end of their tails, a habit probably started by a small injury occasioned by lashing the tail against the bars. In one case the tip of the coecygeal vertebrae was exposed by this self-mutilation. Application twice daily of a strong-smelling non-poisonous antiseptic deterred the Leopards and uneventful healing followed.

Overgrown Claws

An adult Lion, 'Simba', aged between 20 and 30 years, had been 'walking lame' for some months due to the overgrowth of its claws. The animal was confined in a large metal-lined

box with a barred gate and a solid gate at both ends. This box is relatively airtight when the end gates are down, but in view of its large size (six to eight times the total bulk of the lion), a hand insecticide sprayer giving a very finely divided mist was used to administer the chloroform. Cotton wool swabs soaked in 10 ounces of the anaesthetic were placed in the box first and then the sprayer was inserted through a small window. The animal "went down" after about fifteen minutes, showing practically no excitement, and light anaesthesia was maintained for about a further twenty minutes as the feet were drawn out one by one under the end gates of the box. About 30 ounces of chloroform were used in all. Three claws on one forefoot and three on one hind foot had penetrated the 'pads'. All claws on all feet were cut short with bone forceps and the six wounds were forcibly syringed and swabbed with a strong solution of non-poisonous antiseptic, finally being dressed with penicillin and sulphamezathine powder. By the end of the operation the lion was sufficiently recovered to be licking the wounds and walked back from the box into the cage only slightly unsteadily. A very slight lameness still remains some months after the operation, during which time no further treatment has been given. It is possible that this is from other causes as the Lion is aged.

Recurrent Constipation

'Sylvia', a three-year old but poorly developed Lioness, showed recurrent constipation with flatus, distention of the abdomen, etc. Numerous laxatives and purgatives were used with varying success, i.e. Phenolphthalein in 20-grain doses, Calomel 6 grains, Liquid Paraffin daily, etc., but after twice dosing with 10 grains of 'Alten' (May & Baker) the

condition did not recur. This drug is readily taken in the food and has been used successfully also in a Leopard cub, a Cheetah, a Tiger cub and other animals.

Parasitic Infestation

(a) Notoedric Mange

One case of this disease was the only ectoparasitic infestation of clinical significance. It occurred in a young Leopard cub, which arrived showing typical symptoms, i.e. thickening and wrinkling of the skin of the forehead and face, and encrustation of the ears, neck and ridge of back with scabs. The notoedric mites were seen on examination of skin scrapings and treatment with 'Tetmosol' (I.C.I.) instituted. Six dressings were given during five weeks and by the end of this time recovery was apparently complete. The cub licked off much of the dressing, which appeared to cause sleepiness and slight anorexia on the day following each dressing. Two weeks later the condition recurred, probably because of infestation from the cage itself. Recovery was this time much slower and was not complete when the cub was sold.

(b) Endoparasites

The results of 74 faecal examinations carried out during both periods were negative in 18 cases and positive in 56. In a number of cases several reports concern the same animal, its faeces being examined on more than one occasion.

'Ascarid eggs' were found in Bears, a Leopard and a Lioness, and described as "Toxocara sp." in a Wild Cat, a Puma and a Lynx.

'Hookworm' infestation is reported in Leopards, Wolves, Dingos, Tiger cubs, Puma, Arctic Fox, Coyote and Jackal.

Coccidial oocysts were found in faeces from a Fennec

Fox and a Leopard. In the latter they are described as *Isospora felis*.

Eggs merely described as 'strongyle spp.' were reported in a Bear and two Chinese Masked Palm Civets.

Worms resembling *Protospirura* sp. were found in the excrement of a Mongoose, but it is suggested in the report that they may have been vomited by the animal after consuming an infected rodent.

In addition to these 13 reports are of mixed infestations, thus:-

Hookworm and <i>Toxascaris</i> sp.	in Dingoes
Hookworm and <i>Toxocara</i> sp.	in Pumas
Hookworm and <i>Coccidia</i>	in Tiger and Leopard cubs
Hookworm and <i>Trichuris</i> sp.	in Arctic Fox
Hookworm and <i>Capillaria</i> sp.	in Silver Fox
<i>Toxocara</i> sp. and <i>Taenia</i> sp.	in Puma
Whipworm and <i>Isospora</i> sp.	in Arctic Fox
<i>Metastrongylus</i> sp. and Tapeworms	in Silver Fox
Lungworm and <i>Coccidia</i>	in Silver Fox
<i>Capillaria</i> sp., <i>Coccidia</i> and Hookworm in Silver Fox	
<i>Toxocara mystax</i> , <i>Taenia</i> sp. and <i>Isospora</i> sp. in Wild Cat	

Treatment has not usually been required in the case of Hookworm infestation, which appears to be self-limiting in captivity. Where animals can be handled, however, tetrachloroethylene capsules are used. Moderately successful results have been achieved with Arctic Foxes and a young Leopard cub.

In the treatment of Ascarid infestation, Santonin and Calomel given in one dose have proved simple to administer because of the small quantity required, safe when cautiously

used and quite satisfactory in result.

Tapeworm infestation has not often been diagnosed.

'Nemural' (Beyer) was employed with success in a young adult Leopard, resulting in the expulsion of several large taeniform cestodes.

Other Cases

1. On 2/10/51 an adult Raccoon showed an epileptiform convulsion with opisthotonus, champing of teeth, etc. Thirty minutes later the animal was feeding normally. A half grain Phenobarbitonum was given in the food. There was no recurrence until 5/10/51 when the animal showed a staggering gait and apparent impairment of vision afterwards. More phenobarbitone was given. On 6/10/51 it still was somewhat "doped" in appearance, walking with a high-stepping action of the fore feet. Five milligrams vitamin B₁ given by injection. By 10/10/51 the animal appeared normal and there has been no recurrence of the condition over a year later.

2. 'Rikki,' a young adult male Marsh Mongoose, showed a series of clonic and tonic convulsions and fits of maniacal running on 2/1/51. The attacks lasted only a few seconds. Consciousness did not appear to be lost and complete recovery occurred each time. Two doses of 1 grain phenobarbitone were given and after 24 hours the condition did not reappear.

Nine months later, in October, the animal became "stiff" in the hind quarters. Salicylates by mouth and infra-red irradiation were given daily without success. On 15/11/51 an X-ray examination was carried out with negative results. On 27/12/51 a sudden worsening occurred and the posterior paralysis was almost complete. On 10/1/52 a second set of X-ray plates were exposed, the animal being under light ether

anaesthesia to assist relaxation. At the same time the anal glands were manipulated and much secretion expressed. The plates showed nothing, but a slight improvement occurred in the animal's condition and it was seen to stand using its hind legs. Further manipulation of the glands under anaesthetic was carried out on 15/3/52, but this time no improvement followed.

28/4/52 - A course of 'Atophanyl' injections (British Scheering) was commenced, 1cc. being given intra-muscularly into the hind legs alternately for four days and $\frac{1}{2}$ cc. on the fifth day.

No improvement was seen until 17/5/52, when seen to be walking and running freely with arched back. By the end of another week, appeared normal, could be handled with ease, not attempting to bite and apparently felt no pain when lumbar region was handled. This state of health has continued for four months to date.

ORDER PINNIPEDIA (CARNIVORA PINNIPEDIA)

This order includes the sea carnivora of which only Seals and Sea-Lions are kept at Edinburgh.

The Sea-Lions have a large pool and enclosed unheated sleeping quarters. The Seals occupy small enclosures with pools but have no house. All are fed solely on fish, mostly whiting.

Period 1938-49

Ten of the eleven reports concern Seals, mostly the Grey Seal (*Halichoerus grypus*) and at least one Harbour Seal (*Phoca vitulina*) although the species is not always mentioned.

Four of the Seals were young and the reports mentioned gastritis in two cases and ascribed the other two to 'dietary factors.'

Gastritis is also reported as principal finding in one of the adults, another showed enteritis and 'jaundice' and in a third, rupture of the small intestine and subsequent peritonitis are reported.

Pneumonia and sinusitis were the principal findings in two other reports and the tenth is of hernia and hydatid infestation.

One Sea-Lion (*Zalophus californianus*) died from intestinal obstruction with a tightly rolled handkerchief.

Period 1950-51

All of the six deaths were new arrivals in the park with the exception of the Sea-Lion.

050/9. Sea-Lion cub. Rupture of liver and severe intra-peritoneal haemorrhage; killed by adults soon after birth.

040/2. Young Common Seal. This animal was being kept alive by force feeding with fish. After some days it died

after a severe epileptiform convulsion. Roundworms, presumably *Ascaris* sp., were found in the stomach on post-mortem examination, but no other abnormalities were seen. It was presumed that some form of enterotoxaemia was responsible for death.

C50/11 and 12. Two young seals died during the writer's absence and were not examined post-mortem.

C50/10. A young Seal showed only sub-acute bronchitis when examined post-mortem.

C50/16. Adult Sea Lion. This animal showed 'stiffness' of the hindquarters during January, which passed off. In October this 'stiffness' returned, accompanied by apparent abdominal tympany and partial anorexia. 'Alton' (May & Baker) was given as a laxative in the fish and a quantity of soft faeces were passed. Death occurred two days later and post-mortem examination revealed multiple adenocarcinomata of liver, pancreas, spleen and lymph nodes. The origin was possibly the adrenal gland, but the examination was somewhat cursory in view of the decomposed state of the animal.

DISCUSSION - THE CARNIVORES

Several points of interest concerning this order alone are worthy of discussion here.

a) Virus diseases, particularly Infectious Feline Enteritis and those of the Canine Distemper group, appear to have been of very little importance at Edinburgh during the period under review. This is surprising in view of the severe epidemics at other collections. Feline enteritis is reported by Hamerton (1939), Rewell (1948 and 1950) and Osman Hill (1951) in London as affecting twelve or more different species of the Felidae, and Rewell reports the use of vaccination methods with considerable success. Henderson and Taplinger (1951) also refer to vaccination against this disease in the animals in Ringling Brothers Circus. Goss (1942) also refers to Feline Enteritis at the Bronx Zoological Park.

Canine Distemper at London zoological gardens is reported in seven species of the Canidae by Hamerton (1945 and 1946), Hamerton and Rewell (1947) and Rewell (1948) and a detailed account of an outbreak is given by Armstrong and Anthony (1942) at Washington Zoological Park. Three cases are reported at Philadelphia by Fox (1933) in small mammals, but from the reports of that Society the disease does not appear to have been common there. It has also been recorded in the zoological collection at New York by Goss (1942). Osman Hill (1952) reports an outbreak of Canine Para-distemper (Hard Pad) at London.

Some cases may have been overlooked at Edinburgh but there have certainly been no severe outbreaks of either disease. The reason may be connected with the practice of housing most of the carnivora in more or less outdoor cages throughout the

year. In addition the number of dogs and cats entering the grounds is probably much smaller than would occur if they were in a densely populated part of the city as so many zoological gardens are.

b) Although kidney disease has occurred quite frequently only one reference is made to chronic nephritis in the period 1938-49, and one further case seen during 1950-51 which was not responsible for death. Several of the reports, however, mention nephritis without describing it, and these may have been of the chronic interstitial type. Six reports of nephritis are made in Felidae as against three in Canidae, which appears to indicate that wild canines are less frequently affected by chronic nephritis than is the domestic dog. It would seem justifiable to presume that the incidence of the leptospiral infection responsible for canine nephritis is probably low in captive wild carnivores.

Hamerton (1941, 1943, 1945 and 1946) reports chronic interstitial nephritis in Wolves, a Hyaena, a Binturong, a Raccoon-like Dog and a Tiger as well as in several Primates and Rodents.

c) The occurrence of gastric ulcers in a Raccoon, a Kinkajou and a Mongoose is of considerable interest in view of their infrequency in domestic animals. Fox (1933) states that "gastric ulcers are occasionally found in Primates and Carnivores" and they are reported by Hamerton (1939, 1941, 1942 and 1943) at London in several Primates, Rodents, Marsupials and one carnivore, a Coyote, and by Osman Hill (1951) in a Crab-eating Fox. Duodenal ulcers in carnivores are reported by Fox (1927) in a Wolf; by Hamerton (1944), in a Husky Dog and by Hamerton and

Rewell (1947) in a Fox. Rewell (1948) discusses the occurrence of gastric and duodenal ulcers in the London collection. He describes one ulcer in the limited glandular area of a Wallaby's stomach which very closely resembled the type found in man.

Fox (1925) records 21 'peptic' ulcers in 8000 mammals examined. Eight were seen in Carnivores, 5 in Primates, 3 in Ungulates, 2 in Marsupials, 1 in an Insectivore and 1 in a Hyrax. He suggests that the cause in man may be some form of infection and the resistance of animals due to a difference in blood supply to the gastric wall.

d) Among the respiratory diseases of the carnivores, some cases of chronic bronchitis and bronchopneumonia have occurred. This condition appears to have been much less frequent, however, than in the London zoological park where (1942) Hamerton refers to it as "the commonest cause of death among our large Felidae." He suggests that it may be related to the foul air and dusty condition of the house and says that it is less prevalent in the open air conditions of Whipsnade. This may account for the infrequency of the condition at Edinburgh, the carnivores mostly having open air conditions throughout the year.

e) It is difficult to know whether the apparent enlargement of the thyroid gland mentioned in nine reports during the first period was in fact abnormal. Hamerton (1943) states that it is normally large in many Felidae and may persist into adult life, but six of the nine reports at Edinburgh concern canines and several of them refer to 'cystic goitre' so that it seems probable that some of them at least were

pathological. Hediger (1950) quotes Klatt who found enlargement of the thyroid as well as skeletal and other changes in a number of captive Foxes, and who considered the changes to result from the captive environment of the animals.

Fox (1924) remarks that "the susceptibility of carnivorous animals to enlargement of the thyroid body is very well known."

f) The frequency of dietary disease affecting the skeleton has been briefly discussed under "Clinical Notes." There are many references in the literature to the occurrence of rachitis and osteomalacia in captive wild carnivorous animals, e.g. Hamerton (1939, 1940). Regarding other dietary diseases, the difficulty of rearing young seals in captivity is well known (vide Gillespie 1950).

g) Three of the ten reports of neoplasia (eleven reports if that of lymphatic leukaemia in a Leopard be included) concern Raccoons, i.e., one-third of all the Raccoons which died during the period. These animals are only kept in small groups as a rule and though this apparent frequency may be coincidental, it is interesting to note the following three references to other neoplasms in the same species. Adenoma of the thyroid - Hamerton (1944), Carcinoma of nasal bones - Fox (1927) and Carcinoma of the duodenum - Fox (1928).

The occurrence of osteoporosis in a Fox with adenoma of the parathyroid is also of considerable interest in view of the connection of that endocrine gland with calcium metabolism.

h) One Polar Bear during each period has died showing a heavy infestation with *Trichinella spiralis* and it appears that these animals must be especially susceptible to the infestation

or in some way come into contact with it more frequently than other mammals, because Fox (1927) reports two cases occurring at Philadelphia Garden. It is possible that the parasites are carried by rats, although Weidman's analysis of the parasitic burden carried by free rats and mice which is included in many of Fox's annual reports, makes no mention of the parasite. It is improbable also that Polar Bears are any more adept at catching rats and mice than are other carnivores. The ^{probably} infection occurs between capture and arrival at the zoological park as it seems improbable that a suitable intermediate host is available for the parasite in the Arctic.

The frequency of 'hookworm' infestation in newly arrived carnivores has already been commented upon. In general it appears to cause little harm and although the infestation does not disappear for a long time, if at all, the parasite level diminishes with the careful hygienic routine employed.

j) The ratio of deaths among new arrivals to deaths among old stock during the second period was 12 : 12. The figure for new arrivals is mostly made up of animals arriving in poor condition and of young killed at birth.

ORDER RODENTIA (*Rodentia simplicidentata*)

In this order are included all the "Gnawing Mammals" with the exception of the Rabbits and Hares. These are considered separately under Order Lagomorpha because, although they do not differ greatly in anatomical features, diet or housing from the other Rodents, the Rabbits are kept for feeding the reptiles and consequently the type of husbandry employed is very different. This also applies in some degree to the Guinea Pigs, Rats and Mice, but it is felt that the separate section devoted to the Rabbits suffices to show the important points arising from this difference in husbandry.

No attempt has been made to study the various families individually because of the smaller total number of reports dealt with, and the general lack of information of the diseases of Rodents with which to compare findings.

The type of housing varies considerably. Some of the larger Rodents live outside throughout the year and have a small sheltered sleeping compartment. Of these the Beavers and the Coypus have access to water for swimming. The Beavers have a grass-covered paddock, while the Coypus and Porcupines have rock-floored enclosures. Other Rodents occupy wire-fronted cages in the Small Mammal House and some of the smaller Gerbils, Hamsters, Squirrels, etc. are behind glass in the Reptile House. Most of the Guinea Pigs are kept in wood-floored runs in the Rabbitry, where Mice and Rats also live in small breeding cages. Yet other cages containing Mice, Gerbils, Hamsters, etc. are kept in the heated room of the hospital. To generalise, the majority of the small rodents are kept in indoor cages, many of which are heated in the winter, and do not receive feeding by the visitors. The larger rodents are mostly kept in outdoor

enclosures without heat, where they can be fed by the visitors.

All the Rodents receive a vegetarian diet consisting of cooked maize, dry cereals, carrots, lettuce and some fruit according to the preference of the species. In addition the Chipmunks are occasionally given a little offal in an attempt to discourage cannibalism.

Period 1938-49

The number of reports of post-mortem examinations carried out during this period is 136.

The Cardiovascular System

The three reports included here concern a Great Cane Rat (*Thryonomys swinderianus*), death being ascribed to "failure of the right heart," a Golden Agouti (*Dasyprocta aguti*) with myocarditis and also showing nephritis and pneumonia, and a Jumping Hare (*Pedetes cafer*) which showed 'focal necrosis of the heart' in addition to lingual necrosis due to *Fusiformis necrophorus* infection.

The Respiratory System

In 15 reports affections of this system appear as the principal post-mortem finding. The animals are:- 5 Guinea Pigs (*Cavea porcellus*), 3 Golden Hamsters (*Mesocricetus auratus*) 2 Red Squirrels (*Sciurus vulgaris*), 1 Tree Squirrel (*Heliosciurus gambianus*), 1 Palm Squirrel (*Funambulus palmarum*), 1 Siamese Squirrel (*Callosciurus* ?), 1 Golden Agouti and 1 Coypu or 'Nutria' (*Myocastor coypus*).

The terms used to describe the abnormalities include 'pneumonia,' 'bronchitis' and 'congestion of the lungs,' etc. Reports using these somewhat vague terms have been included under this heading only when other findings have been insignificant.

A further twelve reports mention respiratory disease associated with other more important abnormalities. In one report concerning a Coypu, staphylococci were isolated from the pneumonic lung tissue.

The Alimentary System

Excluding parasitic infestations and neoplasia, abnormalities of this system are reported as the principal finding in 26 post-mortem examinations. Eleven of the reports concern the alimentary tract proper and 15 the liver. Three other reports mention secondary findings concerning this system.

The Stomach

Gastritis is reported in a Coypu also showing terminal pneumonia.

Gastro-enteritis is reported in a Forest Squirrel (*Reithrodontomys* ?) and in a Brush-tailed Porcupine (*Atherurus africanus*) where the mucosa of the small intestine had become ulcerated.

'Dilation of Stomach and Duodenum' is reported in a Tree Porcupine (*Coendou* ?).

The Intestines

Enteritis appears as principal finding in four reports a Beaver (*Castor canadensis*), a Guinea Pig, a Siamese Squirrel, and a Patagonian Cavy (*Dolichotis magellanica*). In the last of these coccidia were suspected but not confirmed.

Intussusception is reported once, in the Coypu mentioned above with staphylococcal pneumonia.

Ulceration of the colon occurred in another Beaver, and the eleventh report is of severe enteric congestion in a Coypu believed to have eaten "Red Squills" rat bait.

The Liver

"Cirrhosis" is referred to in reports concerning one Crested Porcupine (*Hystrix cristata*) and three Golden Hamsters.

Acute hepatitis occurred in a Guinea Pig and a Hamster and suppurative hepatitis in a Grey Squirrel (*Sciurus carolinensis*).

Hepatic abscesses or hepatic necrosis are reported in a Coypu, a Great Cane Rat, a Golden Hamster and a Beaver.

The other hepatic conditions reported are 'chronic septic cholecystitis' in a Golden Hamster, 'jaundice' in a Guinea Pig, degeneration of the liver in a Ground Squirrel (? ?) and rupture of the liver in another Golden Hamster.

The Urinary System

Excluding several cases of neoplasia, abnormality of this system is the principal finding in five reports.

Multiple calculi of the calcium oxalate and calcium phosphate types were found in the renal pelvis and ureter of a Jumping Hare.

Nephritis and chronic venous congestion is reported in two Tree Porcupines.

Urethral obstruction with desquamated cells of the uterus masculinus is reported in one Guinea Pig and "bladder lesions" are referred to in another.

Two further reports mention nephritis in association with heart disease.

The Reproductive System

Again excluding neoplastic disease, three of the reports included here are of metritis in two Guinea Pigs and a Spotted Paca (*Cuniculus paca*) and the fourth is of an ectopic pregnancy in a Golden Hamster.

Other Tissues

Two reports are included here, one concerning anaemia in a Tree Porcupine, and the other "suppurative otitis" in a Rat (*Ratus norvegicus*).

Dietary Factors affecting the Skeleton

The only two reports referring to bone disease of this type concern Red Squirrels, the term 'osteoporosis' being used in one, and 'osteomalacia' in the other.

Other Dietary Conditions

In five reports cachexia malnutrition and similar descriptions are used in the absence of other significant findings.

Two reports on Coypus with neoplastic disease make reference to abnormalities of the thyroid gland.

Parasitic Disease

Infestation with ecto- or endoparasites forms the principal finding reported in eleven Rodents.

Ascarid infestation in 3 Mice (*Mus musculus*) and 'roundworms' in a Tree Porcupine.

Spiruroid infestation of the intestines in a Golden Hamster.

Microfilariae in one Tree Porcupine, and 'helminthiasis' 'ulcerative enteritis' and nematode infestation of the blood in another.

'Parasitic cysts' in the liver of a Coypu.

'Sarcoptic mange' in two Capybaras (*Hydrochoerus hydrochoeris*) and in a Golden Hamster with coexistent 'demodectic mange.'

A further seven reports mention parasites in a secondary role, five concerning endoparasites including two of

Ascarids and one of tapeworms, and two concerning fleas and lice.

Neoplasia

Of the nine reports of neoplasia, eight concern Coypus. They are listed below with other findings in parenthesis.

1. Coypu - Multiple benign adenomata of kidneys and liver.
(Thrombosis of left auricle, calcification of aorta)
2. Coypu - Sarcomata of kidney and liver.
3. Coypu - Adeno-carcinoma of thyroid. Four adenomata in uterus.
4. Coypu - Sarcoma of sternum displacing trachea to one side.
Carcinoma of lung.
5. Coypu - Adenomata of kidneys. (Thrombi in vena cava.
Bronchopneumonia.)
6. Coypu - Adeno-carcinoma of one uterine horn and multiple fibromyomata of the other.
7. Coypu - Mixed cell sarcomata in liver, pancreas, lung, lymph glands, portal vessels and kidneys.
8. Coypu - Multiple benign tumours of duodenum and kidney.
(Cystic thyroids. Purulent bronchitis.)
9. Siamese Squirrel - Adenoma of prostate gland. (Fatty infiltration and degeneration of liver.)

Mention is also made in the case of one Guinea Pig of areas of "plexiform haemangioma" in the liver.

Special Diseases

Septicaemia is reported in two Prairie Marmots (*Cynomys ludovicianus*) and a Great Cane Rat. From one of the Marmots streptococci and *Proteus* organisms were recovered and staphylococci were found in the Cane Rat.

Infection with organisms of the Salmonella group is reported in five Mice.

Pasteurella pseudotuberculosis rodentium infection is reported in three Patagonian Cavies and a Guinea Pig.

Mention must also be made here of the report on a Jumping Hare which is classified under the 'Circulatory System' where lingual necrosis due to Fusiformis necrophorus infection was also present. It is possible that the heart lesions were due to the same organism.

Violence

Nine reports are included here in which the principal findings are directly traceable to injuries. The animals concerned are two Golden Hamsters, two Coypus, one Jumping Hare, one Ground Squirrel, one Prairie Marmot, one Cane Rat and one Guinea Pig.

Streptococcal osteomyelitis of the mandible in the Jumping Hare is that of most interest.

Inconclusive, etc.

Of the 33 reports which are included under this heading for various reasons, further comment is necessary in the case of a Coypu and a Beaver which were reported as having been drowned. While it is possible that these animals were drowned, it seems probable that some underlying disease caused them to enter the water to die. A Porcupine in which senility is suggested as the cause of death is also included.

Period 1950-51

Diagnosis is hampered in Rodents by a number of factors. The small size of many species makes difficult the observance of disease symptoms during life and of lesions on post-mortem examination. The animals are commonly kept in groups and

individual abnormality is liable to be overlooked, and sick or injured members of the group are often consumed by the others. The life span of some species is not surely known, and the signs of old age are often difficult to distinguish. Finally, the low body weight renders the smaller species particularly susceptible to temperature changes and to temporary shortage of food.

These factors make the division of the deaths into various categories somewhat more arbitrary than in the other orders of mammals.

The Cardiovascular System

R51/13 A Capybara died after two days in the park. Post-mortem examination was reported as showing myocardial degeneration and hepatic fibrosis.

The Respiratory System

R50/5 and 6, Five West African Gerbils (*Tatera gambiana*)
R51/3, 25, 35.
showed abnormalities of this system almost certainly due to the low temperature of the house in which these tropical animals were kept. Three showed pneumonia, and two severe congestion of the lungs only.

R50/13 A White Rat showed bronchopneumonia.

R50/2 A Gambian Tree Squirrel showed pulmonary emphysema as the sole finding.

R50/1 An old Beaver, showed fibrinous pleurisy and pericarditis from which haemolytic streptococci of Lancefield's Group G were recovered.

Four other Rodents showed respiratory disease associated with more important findings.

The Alimentary System

In view of the small size of the alimentary tract

proper in many of the small rodents, and the speed with which putrefaction takes place, it is, in the writer's opinion, difficult to decide when mucosal congestion, catarrh or other change is truly significant. As no obstructions, impaction or ulcerative processes have been seen, the only cases included under this heading are those concerning hepatic abnormality.

The Liver

R51/17, a newly arrived Beaver, showed circular lesions on the skin of the feet and of unknown origin, only non-haemolytic staphylococci being cultured from the lesions. Minute yellow foci could be seen scattered throughout the liver and caseous nodules were found in the lung, kidney and one mesenteric lymph gland. Histological examination showed small necrotic foci in the liver and spleen which appeared to be of haematogenous bacterial origin, although coliform organisms only could be recovered when cultures of liver tissue were made.

Multiple necrotic foci were also found in the liver of a Guinea Pig R51/36 and a Coypu R50/8.

Two young Gerbils R50/7 and 12 showed foci of acute hepatic inflammation. Haemolytic staphylococci were recovered from the liver of one but paracolon organisms only from the other.

Haemolytic paracolon organisms were recovered from the liver of a Gerbil R50/24 and in another Gerbil R50/30, a Coypu R51/26 and a Chipmunk R51/12 hepatic fatty change was the sole or principal finding.

Liver abnormalities were also found in seven other Rodents classified elsewhere.

The Urinary System

In no case did abnormalities of this system form the

principal post-mortem finding, though some degree of degenerative change was seen in the renal epithelium of one Chipmunk and a Rat.

The Reproductive System

R51/35, an adult female Crested Porcupine showing posterior paraplegia was destroyed. On post-mortem examination the principal finding was endometritis, the causal organism being a haemolytic staphylococcus.

Endometritis was also seen in a Coypu with hepatic disease, and which is included under the heading of Neoplasia.

Parasitic Disease

The four Rodents in which parasitic infestation was the principal finding were, R50/36 a Gerbil and R50/38 a Golden Hamster, both of which showed many roundworms, apparently Ascarids, in the intestine; R50/4 another Gerbil which showed helminth infestation of the liver, and R51/16 a Long-tailed African Rat (? ?).

On naked-eye examination, the liver of this last animal showed numerous small irregular worm-like white areas subcapsularly which in places coalesced to form solid white masses. On histological examination much of the liver tissue was found to be displaced by tightly packed nematode eggs, and although no adults were seen, there is little doubt that the parasite involved was *Hepaticola hepatica*. The Rat had been kept by itself and no doubt was infected before arriving in the park.

Mites of the *Sarcoptes scabiei* group were recovered from ear lesions in a Rat dying from other causes.

Neoplasia

R50/19, an Adult Coypu, is the only Rodent included

here. The principal findings were hepatic necrosis and endometritis, but in the anal region a large swelling was found which, after histological study, was tentatively classified as an adenoma of sebaceous tissue.

Special Disease

R50/32 a Mouse and RF51/38 a Rat showed septicaemic changes which were caused by *Salmonella enteritidis* (var. Dublin), the organism being recovered from the bone marrow in each case.

Haemolytic streptococci (Lancefield Group C) were isolated from the bone marrow of R51/25, a Great Cane Rat. The septicaemia probably originated from an abscess found at the base of one molar tooth.

Septicaemia in RF51/40, another Rat, was considered due to *Bacterium coli* as this organism only was found in the bone marrow and tissues.

Infectious ecteromelia was suspected in a Mouse, R50/28, showing hepatic necrosis, when cultures from the liver tissue proved negative for pathogens.

Violence

In the following 45 animals there was reason to suppose that fighting or other injuries were the principal cause of death. It is quite possible, however, that other factors were in part responsible in some cases.

R51/8, 9, 10, 11, Ten young Crested Porcupines killed at birth
18, 19, 20,
38, 39, 40. by the adults.

R51/23, 26, 34, Six Chipmunks. Parts only of these were
37,
R50/33, 34. recovered. Cultural examination of the bone

marrow was made on two occasions with negative results.

R51/19 to 21, Twelve young Guinea Pigs killed at or soon and 27 to 36.

after birth by the adults.

R51/6, 7. Two African Dormice. Severe fighting injuries were dressed the day before death which was presumed due to shock.

R50/44, Ten Golden Hamsters. Severe injuries were seen in R51/1, 24, and 27-33. several of these, but in others only parts were recovered. One bacteriological examination of bone marrow was negative for pathogens. It is possible that chilling was responsible for some of these deaths.

R51/9. A Guinea Pig. Died the day after operation on an abscess, possibly from the chock of being handled.

R50/10, 20, Three Gerbils. From the bone marrow of one of R51/22. of these injured animals haemolytic staphylococci were isolated.

R50/14 A Mole Rat (Georychus ?) died the day after arrival. It showed severe injuries and broncho-pneumonia .

Inconclusive, etc.

Three animals were destroyed. R50/21 and 22, two Beavers, to save attacks by new arrivals, and R51/2, a Gambian Tree Squirrel which showed posterior paralysis possibly due to senile changes.

The other eleven Rodents included here require no further comment.

ORDER LAGOMORPHA (Rodentia duplicidentata)

This Order includes only Rabbits and Hares and is considered separately because the Rabbits are kept to be killed for feeding the reptiles and other stock. This means that more Rabbits are continually being bought in from various sources to replace those killed, and there is little chance of establishing a disease-free group. A few bucks and does are kept for breeding in individual hutches, but the majority of the Rabbits are kept in small wooden-floored pens with straw and sawdust litter. The house is unheated and the diet consists of cut grass, green vegetables and some grain.

Period 1938-49

The Respiratory System

Reports of acute bronchopneumonia in one Rabbit (*Oryctolagus cuniculus*) and of embolic pulmonary abscesses in another are the two included here.

A further report is included under Special Disease.

The Alimentary System

'Acute haemorrhagic enteritis' is reported in one Rabbit and 'enteritis' in two Mountain Hares (*Lepus timidus*) one of which had an associated localised peritonitis and a sub-cutaneous 'dermoid cyst.'

The Urinary System

The only abnormality referred to is cystitis in one report included under 'Neoplasia.'

Parasitic Disease

There is only one report of helminthiasis as principal finding, that of *Trichostongylus* sp. infestation in the intestine of a Rabbit. Helminths are also mentioned in two other reports.

Coccidial infestation is the principal finding in 30

reports on Rabbits and in two others it was found associated with pseudotuberculosis infection.

Neoplasia

The only report is of a spheroidal cell carcinoma of the uterus with secondary metastasis in the lungs in a Rabbit also affected with cystitis.

Special Diseases

In 11 reports concerning Rabbits, infection with *Pasteurella pseudotuberculosis rodentium* is the principal finding.

Labial necrosis and bronchopneumonia due to *Fusiformis necrophorus* infection, one case of 'Favus' and one of 'Ringworm' are the other three reports, all concerning Rabbits, which are included here.

Violence

One report of a Rabbit with multiple abscesses probably due to wounding is the sole report.

Inconclusive

The two reports concern a Rabbit and a Hare (*Lepus europaeus*).

Period 1950-51

The Respiratory System

Bronchopneumonia occurred in one Rabbit, RF51/7. No bacteriological examination was made. A few coccidia were present in the small intestine.

Pulmonary congestion was the principal finding in two emaciated Rabbits, RF50/45 and 46, which showed slight hepatic abnormalities.

An early bronchitis was also found in a Rabbit with renal disease.

The Alimentary System

Three examinations showed intestinal disease not coccidiosis, as the principal finding. One was a young Rabbit, R50/5, where congestion of the small intestine was the sole finding, and another, an older Rabbit, R50/11, showing a few coccidia in the liver and severe congestion of the intestinal wall which appeared to have atrophied at one point below the congested area, presenting the appearance of a fibrous thread. No bacteria were isolated in either case. A third Rabbit, R50/33, showed ulcers of the pyloric stomach and duodenal congestion and some fatty change in the liver. Unfortunately bacteriological examination of the intestine was not made, but cultures of the bone marrow were negative for pathogens.

Liver abnormalities formed the principal finding in two reports.

Fatty change in a Scottish Hare, R51/4. This was probably dietary in origin as these animals rarely survive many months in captivity.

Fatty change in a young Rabbit, R51/4, cultures from bone marrow and intestine being negative.

Liver abnormalities are also mentioned in four other reports classified elsewhere.

The Urinary System

Only one death appeared primarily due to renal disease, the Rabbit R51/18 showing considerable degeneration of the tubules secretory tubular epithelium. These contained a number of hyaline casts. Bacterium coli was the only organism recovered from the kidney tissue and early bronchitis was also present.

The Reproductive System

Severe post-partum haemorrhage due to prolapse of the

uterus caused the death of one adult doe, RF51/22.

One case of uterine infection is classified under the Special Disease heading.

Parasitic Disease

Only in one Rabbit, RF51/23, was the number of coccidia found adequate to permit diagnosis of death from coccidiosis. Here there were large numbers of eosinophil leucocytes in the intestinal mucosa.

A few coccidial oocysts were found in the liver or intestine of three other Rabbits only, despite regular careful examination of liver substance and of scrapings of intestinal mucosa.

No roundworms at all were seen, but on a number of occasions *Taeniapisi formis* cysticerci were found attached to the abdominal wall and viscera.

Special Disease

From the bone marrow of one Rabbit, R51/6, *Bacterium coli* was isolated and a septicaemia is therefore considered probable as in another case where it appeared to arise from a uterine infection, R50/8.

Pasteurella septica was isolated from another Rabbit's bone marrow, R51/17. This animal also showed a degree of hepatic fatty change and severe injuries.

Violence

Injuries are believed responsible for the death of 14 Rabbits, mostly younger animals sharing pens with adults. In five of these cases bacteriological examination of the bone marrow was made, all with negative results. One of these had overgrown teeth which may have made feeding difficult.

Inconclusive, etc.

Six Rabbits were not examined post-mortem.

One affected with conjunctivitis and subcutaneous abscesses was 'killed by order'.

Nine were undiagnosed, one giving a negative result on bacteriological examination of bone marrow.

CLINICAL NOTES (RODENTIA AND LAGOMORPHA)

Little clinical work has been required on Rodents.

Ether inhalation anaesthesia has been used on two or three occasions, e.g. in clipping of an overgrown incisor tooth in a Ground Squirrel, and in a Golden Hamster to allow an abscess to be opened. Only light narcosis was required but the anaesthetic seems quite satisfactory.

Sulphamezathine in the food has been used on an empirical basis for rabbits in groups with suspected coccidiosis. The results are difficult to assess.

Psoroptic mange in the ear of a rabbit was responding to treatment when the animal was used for feeding purposes.

DISCUSSION - THE RODENTS

The division of the Rodents into the two orders Rodentia and Lagomorpha for study, gives an opportunity of comparing the disease picture in the same type of animal under different methods of husbandry. The principal points of interest are the high incidence of coccidiosis and pseudo-tuberculosis infection in the changing stock of Rabbits compared to the incidence in the established Rodents. It is probable that the Rabbits became infested and was never properly cleaned before the arrival of new stock. If foreign Rodents had arrived in a similarly diseased condition, it is possible that the most severely affected animals would have died and the remainder reached equilibrium with the parasite, or all would have died and the infection would have disappeared from the enclosure even without thorough disinfestation before a new batch of the same animal arrived from abroad. During 1950 and 1951 few deaths from either of these diseases have occurred among the Rabbits which were transferred to a different house in 1949, thus confirming the supposition that the old house had become infected. The principal cause of death in the new pens has been violence due to overcrowding, failure to separate the sexes and the introduction of new stock into pens already occupied.

A number of other points of interest remain to be considered.

a) The frequency with which Rodents are killed and injured by their companions appears to be equally high at London. It is commented upon by Osman Hill (1951) and Rewell (1950) who states that "especially among Rodents the body may be so mutilated that it is impossible to tell whether

or not the animal is ill." Injuries in Golden Hamsters are mentioned also by Rewell (1948).

b) The occurrence of neoplasia in eight (possibly nine) Coypu out of a total of only nine (possibly ten) cases in all Rodents is a matter of considerable interest. Only a small group of these animals is kept and they are rarely replaced as they keep up their number by uncontrolled inbreeding, which may have some bearing upon this frequency of neoplasia. Although no reference has been encountered in the literature to any particular susceptibility in this species, Rewell (1948b) describes a sarcoma of the tibia, Hamerton (1939) two cases of neoplasia of the thyroid gland which he states to be "unusual in this species" and (1941) a renal adenocarcinoma. Fox also reports renal hypernephroma in one Coypu and adenocarcinoma of the lung in another (1924), a uterine carcinoma in a third/and (1925) an adrenal adenoma in a fourth (1933). This would seem to indicate at least that neoplasia is not uncommon in the species.

Ratcliffe (1932b) finds a high incidence of neoplasia among Rodents as a whole and particularly among the mouse family Muridae, but makes no reference to the closely related Myocastoridae, the Coypu family.

No accurate record of the age of the Coypus at Edinburgh is kept and although they were probably all old animals, many other species of Rodents are kept which reach a similar age in captivity and yet show no comparable frequency of neoplasia. It is interesting to speculate upon the possibility of hereditary factors playing a part in this in-bred group. Ratcliffe (1940) reports the familial occurrence of renal carcinomata in four Rhesus Monkeys, but the evidence in his cases was of a much more definite nature.

c) One reason for the apparently low incidence of disease of the alimentary tract has already been given, that is the difficulty of diagnosis post-mortem, although there may be a real resistance to infection in addition. The frequency of liver disease, however, makes it seem more likely that intestinal lesions have been overlooked. Rewell (1950) suggests the occurrence of virus hepatitis in Rodents at London, and Ratcliffe (1945^a) refers to virus entero-hepatitis of Guinea Pigs, and it is possible that such diseases occur sporadically at Edinburgh and are overlooked.

One case of gastric ulceration in a Rabbit was seen. Hamerton (1942) refers to a similar occurrence in a Patagonian Cavy.

d) Mention has been made of the frequent occurrence of *Pasteurella pseudotuberculosis* infection in the Lagomorpha. This disease is more commonly found in Guinea Pigs, and Ratcliffe (1945^b) states that the infection is usually sporadic and inapparent in other mammals. (See also Appendix, concerning 1952). Ratcliffe also discusses Salmonellosis among laboratory Rodents due to *S. enteritidis* as were the cases reported here, *Pasteurella aviseptica* infection, virus ecteromelia in mice and many other Rodent diseases.

The infrequency of tuberculosis in Rodents is explained by him as being due to the small chance they have of becoming infected.

There is a possibility that 'mucoid enteritis' may have been responsible for some of the deaths among young rabbits as two litters of these were from the same doe and died at a similar age showing little on post-mortem examination. The disease is described by Muir (1949) as are many Rodent diseases

of a rather indefinite nature, some of which may have occurred here and been overlooked.

e) A photograph of hepatic parasitism exactly similar to that appended concerning the Long-tailed Mouse, is given by Fox (1923). *Hepaticola hepatica* infection is reported by him frequently in Prairie Marmots and other Rodents, and in several of his reports (1930, 1932, etc.) Winsor describes its occurrence in the common rats infesting the Philadelphia zoological gardens. The case at Edinburgh was sporadic and nothing similar has since been seen. The life cycle of the parasite is not fully understood, but the nematode apparently reaches the liver, matures and becomes converted into a bag of eggs which await consumption of the host animal for further development. Nicoll (1911) reports the occurrence of *Hepaticola hepatica* in a European Hare in Britain.

f) The infrequency of skeletal disease is worthy of mention and may be connected with differing metabolic requirements in the Rodents from the other orders. The two cases of thyroid enlargement are the only two reported outside the order Carnivora.

ORDER PROBOSCIDEA.

Only the Indian and African Elephants are included in this order.

At Edinburgh only one Elephant is kept, being housed in a heated building and exercised daily for most of the year. It is fed on hay, straw, roots and some grain.

The one death was 'Sandra' and adult female Indian Elephant (*Elephas maximus*), which was destroyed by shooting. The post-mortem report refers to the presence of renal calculi, cystic calculi and chronic cystitis and also to hepatic fibrosis and abscess formation. The animal was in an emaciated condition. In addition inflammation of the superficial coronary tissues was found.

ORDER PERISSODACTYLA

This order includes the odd-toed Ungulates, of which there are but three families:- Equidae, the Horse, the Ass, the Zebra, etc.; Rhinocerotidae and Tapiridae.

Only a small number of these animals are kept at Edinburgh, and the two Rhinoceroses which arrived in 1952 were the second and third ever to reach the park.

The Zebras and Tapirs are kept in small grass paddocks and the Donkeys and an occasional Horse or Pony are kept similarly or in one of the 10-acre pastures with the sheep.

A grain ration is given to those in the small paddocks, and all have contact with the visitors.

Period 1938-49

The thirteen reports are listed individually below.

1. Donkey and Pony Hybrid - Congestion of the lungs. Death
(Equus ?)
apparently due to shock.
2. Zebra (Equus burchelli ?) - Impaction of colon.
3. Horse (Equus caballus) - Rupture of stomach.
4. Horse - Gangrenous enteritis and subsequent
peritonitis.
5. Shetland Foal - Jaundice due to destruction of
bile duct. Also some cerebral
congestion.
6. Horse - Purulent nephritis. Cystitis.
Also enteric lithiasis.
7. Bahrein Donkey - Acute haemorrhagic cystitis,
hydronephrosis due to blockage of
the ureter by x papillomata.
8. Donkey - Strongyle aneurism. Strongyle
larvae in peritoneum.

- 9. Zebra - Extreme emaciation. Canalised strongyle thrombus of the ileo-caeco-colic vein.
- 10. Tapir - Impaction of large intestine with sand.
- 11. Tapir - Actinomycosis of head associated with stenosis of the pharynx and oesophagus. Death due to enterotoxaemia.
- 13. Tapir - Suppurative osteomyelitis of right ramus of mandible with secondary suppurative pleurisy and right-sided bronchopneumonia. A Staphylococcus and a B-haemolytic Streptococcus were recovered from the tissues.

Period 1950-51

There were no Tapirs in the collection during this period and only two deaths occurred in animals of the order.

U51/13. An aged Shetland Pony over 20 years of age, was found prostrate and comatose with laboured respiration. Destroyed by 'humane killer'. The principal post-mortem findings were localised ventricular endocarditis and ulceration of the rectal mucosa. A number of small emboli were also found in the small vessels of the intestinal wall, possibly arising from a verminous aneurism. Bacteriological examination was negative for pathogens.

U51/15. A Donkey foal died at the age of six weeks. Seen lying down but apparently normal at 9.30 a.m. and found

dead three hours later. The only abnormalities found were petechiation of the lungs and congestion of the tonsillar lymph tissue. Bacteriological examinations were negative. The cause of death was possibly enterotoxaemia. At a later date the mammary glands of the mare which bore the foal became enlarged, and a haemolytic streptococcus was recovered from the milk. After treatment with intra-mammary penicillin, examination of the milk was negative for pathogens. The relation between^{the} maternal infection and the foal's death is not known.

ORDER ARTIODACTYLA

This order includes the even-toed Ungulates, of which there are ten families. Species of only seven of these have been kept at Edinburgh. Deaths are recorded in families and in view of the considerable anatomical difference between them they are considered separately.

FAMILY BOVIDAE

The principal divisions of this family are Cattle, Sheep. Goats, Antelopes and Gazelles, and the housing and diet of these animals varies greatly. A few indigenous Highland Cattle are kept in the large grass paddocks, as are the Soay and Mouflon Sheep. The foreign cattle occupy concrete-floored yards with unheated houses attached. Barbary and other Wild Sheep are housed similarly or in mainly rock-floored paddocks. The Nigerian Sheep and Goats are kept in small grass paddocks. The Antelopes and Gazelles are provided with a house, heated in

the cold weather, and solid-floored yards, and in addition there is controlled access for the larger Antelope to a small grass paddock. Grain, hay and some cut grass are fed to all except those animals occupying the large grass paddocks, in quantities depending on the amount of grazing available.

Period 1938-49

Reports concerning 68 animals of this family are available for this period.

Cardiovascular System

The three reports included here refer to 'interstitial myocarditis' in a Mouflon (*Ovis musimon*), 'endocarditis' in a Yak (*Poephagus grunniens*) also affected with bronchopneumonia, and 'mucoid degeneration of the aortic intima' in a Barbary Sheep (*Ammotragus lervia*).

The Respiratory System

Excluding one report of pulmonary tuberculosis, nine reports mention abnormalities of this system as the principal finding, while a further 12 describe them associated with more important findings.

Seven of the nine reports included here refer to 'pneumonia' or 'bronchopneumonia' in two Mouflon, a Soay Sheep (*Ovis aries*), and Indian Antelope (*Antilope cervicapra*), a Yak, a Nilghaie (*Boselaphus tragocamelus*) and a Harnessed Antelope (*Tragelaphus scriptus*). The last two of these animals also showed other important findings.

The other two reports concern a Mouflon with 'peracute inflammation of the lungs' and a Soay Sheep with bronchitis and pulmonary oedema and congestion.

The Alimentary System

Excluding parasitic disease and neoplasia, disease of

the alimentary system forms the principal finding in 17 reports and in a further three is of secondary importance.

The Stomach

Traumatic injury and destruction of the pylorus is reported in a Goat (*Capra hircus*).

Impaction of reumen and reticulum is reported three times; in a Goat, a Mouflon and an African Buffalo (*Syncerus caffer*).

Abomasitis is reported in a Goat and a Mouflon, and 'gastro-enteritis' in another Mouflon. No mention is made here of parasitic infestation.

The Intestines

Enteritis is reported five times, in a Barbary Sheep, a Gazelle (*Gazella* ?), a White Oryx (*Oryx leucoryx*), a Soay lamb and a Mouflon. In the lamb, death was considered due to an entero-toxaemia.

Strangulation of the small intestine is reported in an Indian Antelope.

'Inflammation of the large intestine' was apparently responsible for the peritonitis reported in a Crested Duiker (*Cephalophus* ?).

The Peritoneum

'peritonitis' appears as the principal finding in three reports concerning a Bharal (*Pseudois nahoar*), an Indian Antelope and a Mouflon lamb where there was an associated 'pancreatitis.'

No reports mention hepatic or pancreatic disease as a major finding and of the five reports mentioning disease of the stomach and intestines which are classified elsewhere, the only one of interest is strangulation of the bowel in an India

Antelope with traumatic hernia.

The Urinary System

Abnormalities of this system are mentioned in eight reports, in six of which they form the principal finding.

Renal calculi are reported in two African Buffaloes and three Nylghaie. In one Buffalo they formed the principal finding, being of the 'mulberry' type and having apparently caused general oedema. In two of the Nylghaie also they were principal finding and in one squamous metaplasia of the pelvic epithelium, pyelitis and scarring of the cortex are reported.

The three other reports concern urethritis and rupture of the bladder in a Goat, 'distention of the bladder' in an Indian Antelope where this is reported as sole finding, and uraemia arising from an obstructive balanitis in a European Bison (*Bison bison*).

The Reproductive System

Only two reports mention abnormalities of this system, one being the obstructive balanitis included above and the other of chronic endometritis in an emaciated Indian Antelope classified under the heading of Dietary Disease.

Dietary Factors affecting the Skeleton

Only one report is included here, that of a Mouflon with multiple fractures and no suggestion of traumatic origin.

Other Dietary Factors

In six reports emaciation or cachexia form the principal finding and no mention of parasitic infestation is made. These concern three Goats, a Gazelle, a Mouflon and an Indian Antelope.

Parasitic Disease

Parasitic Disease

Parasitic infestation is referred to in 14 reports, in 13 of which it appears to be the principal finding.

Infestation with nematodes of parasitic gastro-enteritis type appears to have been the cause of death in three Goats, two Mouflon, a Ewe of an unnamed species and a White Oryx. The only reference concerning the species of the worms was in one Goat where they were identified as *Haemonchus* sp.

The other reports refer to 'enteritis and anaemia' in a Mouflon due to heavy infestation with *Trichuris* sp. and intestinal strangulation due to distortion of the mesentery by large numbers of *Cysticercus tenuicollis* cysts in a White Oryx.

Verminous pneumonia is reported in three Goats, one of which showed intestinal papillomatosis and is therefore included under Neoplasia.

Hepatic 'tapeworm cysts' were the principal finding in a Duiker.

Hydatid cysts were reported in the lungs of an Indian Antelope dying of other causes.

Neoplasia

The sole report of any neoplastic condition in the Ungulate reports for this period concerns intestinal papillomatosis in a Goat dying of verminous pneumonia. It is possible that the papillomata may have been of other than neoplastic origin, but the report is included here.

Tuberculosis

"Acute intestinal tuberculosis" is reported in a White Oryx and "tuberculous nodules in the lung" in a Crested Duiker.

Violence

Of the eight reports included here, six refer to

injuries, those of interest being 'traumatic hernia' and strangulation of the bowel in an Indian Antelope and fracture of the pelvis in a Bison. Hernia is also reported in another Indian Antelope which showed severe bruising.

The two other reports are again of Indian Antelope, one showing 'cardiac haemorrhage' considered due to shock and one dying at birth.

Inconclusive

The two reports concern a Duiker and a Mouflon, in the latter poisoning being suspected.

Period 1950-1951.

18 Members of the family Bovidae have died during the two years.

Bovines

The only losses among the true cattle have been two European Bison calves, U50/11 and U51/8, born of the same cow in successive years. This cow had a poor breeding record before arrival from the Woburn herd and apparently gives but little milk and is generally a 'poor mother.' In 1950 the calf died after two days with the mother and coliform organisms were recovered from lung and intestine. In 1951 it was removed in a weak condition after 48 hours, not having been seen to suckle. Feeding by stomach tube, glucose saline subcutaneously and penicillin intra-muscularly did not prevent it dying the following night. On post-mortem examination bruising was found in the kidney region, presumably caused by the cow stepping on it, and coliform organisms were recovered from the bone marrow.

Ovines

One Ronaldsay Ram (*Ovis aries*), one Fat-tailed Ram
two Barbary Sheep
(*Ovis aries*), two Barbary cross-bred sheep/and three Nigerian
Sheep (*Ovis aries*) died during the period. In the first four
of these cases symptoms when seen, were progressive loss of
condition, weakness, anaemia, anorexia, coma and death.
Prolonged treatment was given to both the rams without success.

Post-mortem findings were as follows:-

U50/6. Ronaldsay Ram. Emaciation, etc. Mild verminous
bronchitis (worm species not identified). Sarcocysts
in some muscles. Parasitic gastro-enteritis, the
faeces showing an egg count per gram of 3,500 Strongyles,
3,800 strongyloides, 100 Haematodinous sp. and a few
Trichuris sp.

U51/4. Fat-tailed Ram. 14 years of age. Emaciation, loose,
sharp-edged teeth, heavy tapeworm infestation.

U50/9. X-bred Sheep. Yearling female. Emaciation. Parasitic
gastro-enteritis. 4,500 Trichostrongylus Axei
recovered from bowel.

U50/10. X-bred Sheep. Adult female. Bronchopneumonia and
pleurisy due apparently to *Corynebacterium pyogenes*
infection. Some trematodes in liver tissue.

One of the Barbary Sheep, U50/13, was an aged female
newly arrived in poor condition. Examination post-mortem
revealed a number of caseous abscesses in the lung tissue, in
smears from which acid-fast bacteria could be seen, tuberculosis
being taken to be the cause of death. The other was a new-
born lamb, U51/6, killed by the ram.

Two of the Nigerian Sheep were adult ewes and the
other a two months old lamb. Preventitive anthelmintic

dosage with phenothiazine had been carried out in the case of the adults some months previously. The three sheep formed part of a small flock, kept in a very small grass paddock and allowed to inbreed without restriction for two or more years. The post-mortem findings detailed below were indefinite, the parasitic level appearing to be too low to cause death, although it would doubtless account in part for the animals' debilitation. Some form of enterotoxaemia was probably actually responsible for death in all three cases.

U51/10. Adult Ewe. General condition thin. The principal post-mortem findings were severe congestion of the abomasal mucosa with some intestinal congestion and increased prominence of the mesenteric glands. 1000 *Trichostrongylus Axei* were recovered from the abomasum and 5000 from the intestines. Bacteriological examination of bone marrow was negative and the alimentary contents proved negative for arsenic, a weed-killer containing that substance having been employed in the area.

U51/11. Adult Ewe. This animal died in my absence, General condition thin. Petechiae were reported on the epicardium, there being an increase in pericardial fluid and slight congestion of the stomach and intestines. Bacteriological examination of bone marrow proved negative and no acid-fast bacilli were seen in an examination for Johne's disease. 3500 *Trichostrongylus Axei* were recovered from the abomasum and 200 *Trichostrongylus* sp. from the small intestine. Death was considered due to enterotoxaemia.

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102.

U51/12. Lamb. Seen scouring before death and treated with Phthallyl sulphathiazole without success. On post-mortem examination the animal was found to be in thin condition. There was some serosanguinous fluid in the abdomen, epicardial petechiation, and the mesenteric glands were prominent. 350 Trichostrongylus Axei recovered from abdomen and some coccidia from intestines. Bacteriological examination of the bone marrow and intestine was negative for pathogens. Histological examination revealed only slight changes in the liver, kidneys and lungs.

Caprines

An adult Nigerian Goat, U51/9, was destroyed because of a progressive distortion of both fore-feet. This animal had previously shown a form of lactation tetany when suckling two young kids and had recovered on administration of calcium diphosphate supplement in the diet. After recovery the goat was returned to pasture and later she was found to be walking on the inner wall of the inner 'claw' of both fore-feet. Despite hoof paring the condition became increasingly exaggerated until the animal stood virtually upon the fetlocks, the forefeet projecting out sideways. Otherwise the animal appeared to be in perfect health and was still suckling the kids. It was thought at the time that the cause was some arthritic condition but no such disease was found on post-mortem examination, and so presumably the condition was due to calcium or other deficiency.

The other death was a six months old kid, U51/1. This had been bullied by the old ram. On post-mortem examination the principal findings were emaciation and intestinal congestion. Unfortunately parasitological examination was not

carried out but it seems certain that parasitic infestation was the principal cause of death.

Antelope and Gazelles

The only Gazelle to die was U50/3, Speke's Gazelle (*Gazella spekei*). This showed ulcerations of gum, palate and rumenal wall from which *Fusiformus necrophorus* was isolated and, in addition, a vesicular adenomatous enlargement of the thyroid gland. Death was probably due to inanition caused by difficulty and pain in feeding.

U51/5, a young Duiker, one month old, died two days after arrival. No abnormalities were found and death presumed due to change in environment.

Three Harnessed Antelope died. The first two, a young adult male, U51/3, and a six weeks old calf, U51/2, died a few weeks after arrival, showing no symptoms and no post-mortem findings excepting a severe congestion of all lung tissue. Death was almost certainly due to the low temperature of the unheated house.

The third, a young adult female, U51/7, and dam of the calf which died, was moved to heated quarters. It survived until the summer, when it became reluctant to walk. The front hooves were overgrown and one was trimmed, but the second was left in view of the animal's extreme nervousness. It was examined again a few weeks later and died during the night. Post-mortem examination showed nothing except severe congestion of the posterior lobes of the lung. Bacteriological examination of bone marrow and of other tissues was negative in each case.

FAMILY GIRAFFIDAE

Only one Giraffe is kept at one time at Edinburgh, occupying a heated indoor house with a small paddock attached. The diet consists of grain and vegetables and in addition to the grass which it crops in the paddock, it is from time to time given bunches of twigs and leaves from hawthorn and other trees.

Only one death is recorded in either period, an adult male Giraffe (*Giraffa camelopardalis*). The report mentions principally poor general condition, arthritis and fractures of the mandible and other bones, the cause presumably being a war-time diet, deficient in nutrients as well as in calcium phosphate.

FAMILY CERVIDAE

This family includes the many species of deer. They are housed at Edinburgh as are the Bovidae, in large and small grass paddocks and in solid-floored yards. Heated accommodation is provided only occasionally for Barking Deer and other delicate species.

Diet is as the Bovidae.

Period 1938-49.

22 Reports concern the members of this family during this period.

The Alimentary System

'Enteritis' is the principal finding in five Fallow Deer (*Dama dama*), in two of which there was an associated pneumonia. In one it is described as haemorrhagic and abomasitis was also present. There is no mention of the causal agent, although one bacteriological examination at least was carried out, only *B. coli* being isolated.

'Foreign body gastritis, ascites and pleural effusion' is reported in a Reindeer (*Rangifer tarandus*) and abomasitis in a Hybrid Deer.

Another Reindeer was emaciated due to loss of teeth.

The Urinary System

The one report included here is of acute glomerulonephritis in a Roe Deer (*Capriolus capriolus*).

Dietary Disease

One Reindeer in poor condition showed only congestion of the lungs on examination.

Parasitic Disease

Verminous pneumonia due to *Dictyocaulus vivipara* infestation is reported in a Roe Deer, which showed the following other parasites:-

- | | | |
|-----------------|---|--|
| Stomach | - | <i>Haemonchus contortus</i> , <i>T. axei</i> ,
<i>Spiculoptergia spiculoptera</i> . |
| Small Intestine | - | <i>Ostertagia</i> sp. |
| Large Intestine | - | <i>Oesophogostomum venulosum</i> ,
<i>Trichuris ovis</i> . |

Special Disease

Five reports are included here. Two are of 'Gas Gangrene' in a Red Deer and a Reindeer, one of suspected 'pulpy kidney' in a Reindeer and one of suspected 'Navel Ill' in a Fallow Deer. The fifth is a septicæmic condition of unstated origin in a Roe Deer.

Violence

Injuries are the principal finding reported in a Hybrid Deer and two Fallow Deer.

Inconclusive, etc.

Two Fallow Deer were too decomposed for diagnosis. A Muntjac (*Muntiacus muntjak*) was found to be in a state of advanced pregnancy and may have died during labour. A sero-sanguinous exudate was found in the pleural pericardial and abdominal cavities.

Period 1950-51

The one death was a young adult Axis Deer (*Axis axis*), U51/14. This animal was found dead shortly after being released into a large area of grazing. A dog had been seen chasing it on the previous day, and the post-mortem findings of increased pericardial and abdominal fluid, petechiation of the serous coat of the stomach and some degenerative change in the renal tubules are compatible with death from shock. Bacteriological examination of bone marrow was negative for pathogens.

FAMILY CAMELIDAE

This family includes only the two species of Camel and the Lama, Guanaco, Alpaca and Vicugna.

The Lamas have mostly been kept in the large 10-acre paddocks at the top of the hill, running with sheep. The camels of both species have occupied an unheated house with a small yard and grass paddock attached. The Lamas receive some hay and a small quantity of grain and roots in addition to the grazing, while the Camels receive a larger quantity of the same in view of the limited grazing, and also some green vegetables.

Period 1938-49

The Cardiovascular System

The one report included here is of thrombus of the pulmonary veins in a Lama (*Lama glama*).

The Respiratory System

Four reports only mention respiratory abnormalities, in three of which they appear to be the principal finding.

These are:-

Inhalation pneumonia in a Lama

Pulmonary and hepatic congestion in a Lama.

Double pneumonia, hepatic cirrhosis and worm cysts
in an Alpaca (*Lama Pacos*).

The fourth, a report of pulmonary thrombosis and emphysema, is included under the Cardiovascular System.

Alimentary System

Abnormalities of this system are referred to in nine reports, not including the cases of parasitism, and in six of these they appear to be the principal finding. These are:-

Abomasal inflammation of varying degree in an Arabian Camel (*Camelus dromedarius*), where described as

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haemorrhagic; four Lamas, two with hepatic worm cysts and one
(Lama huanacos)
with hepatic cirrhosis, and a Guanaco/with emaciation and
catarrhal enteritis.

Dietary Disease

It is realised that the influence of dietary factors has probably been very great on the mortality picture of this family particularly. The four reports included here, however, are the only ones in which the findings mentioned have indicated a dietary deficiency as the principal factor involved.

All four are Lamas, two reported as showing 'cachexia,' one with 'emaciation and inanition' and one with 'abomasitis,' 'emaciation' and 'multiple fractures.'

Parasitic Disease

Fifteen reports mention the presence of parasites and in 10 of these they appear to have been the principal finding.

In six of these reports no identification was made, i.e.,

Four Lamas showing parasitic gastritis, enteritis, emaciation, etc.

Lung and enteric infestation in a Camel.

Lung infestation, emaciation, oedema, in a Lama.

The remainder are reported as follows:-

1. Bronchopneumonia due to *Dictyocaulus vivipara*, ~~and~~ *Camelostomylus mentulatus* infestation of the abomasum and osteomyelitis of the mandible in a Bactrian Camel (*Camelus bactrianus*).
2. Parasitic gastro-enteritis and emaciation in a Lama due to infestation with:-

1,200 *Camelostomylus* spp.

5,300 *Trichostrongylus* spp.

131 *Trichuris* spp.

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3. Emaciation, chronic pleurisy, gastritis, ulcerative enteritis due to infestation with

1,500 Trichostrongyles	Abomasum
180,000 Trichostrongyles	Small Intestine
8,000 Trichuris	Large Intestine

in an Arabian Camel.

4. Verminous pneumonitis due to *D. vivipara* and an infestation of *C. mentulatus* and *T. axei* and *T. vitrinus* in a Hybrid Camel.

The five reports, where parasites did not appear to be the principal finding, were of liver infestation in two Lamas an Alpaca and a Bactrian Camel and 'worms' in a Camel with Aspergillosis.

Tuberculosis

The one report concerns a Lama with 'widespread tuberculous lesions.'

Special Disease

The two reports included here refer to multiple abscesses in an Alpaca, and tracheitis and bronchitis in a young Camel also affected with verminous enteritis. This last report is of some interest because the causal agent of the respiratory disease was found to be a mould of the genus *Aspergillus*.

Violence

A Lama with a broken neck and a Bactrian Camel with enteritis are the only two animals of the family reported as dying of injuries.

Period 1950-51

Only one Camel was kept in the park during this period, all six deaths in this family being Lamas. These six deaths, five adults and one new born, were from the same small herd of nine animals occupying the top 10-acre paddock which was also being grazed by sheep. The pasture was very poor, having been over-grazed for years without rest. The deaths occurred during 1950, none during 1951, treatment in each case being ineffective.

U50/1. Adult female. Aborted dead foetus in the previous month. Showed conjunctivitis, progressive loss of condition, prostration, coma and death. Post-mortem examination revealed emaciation as the principal finding and parasites recovered from the small intestine were 1160 *Trichostrongylus* sp. and some *Nematodirus* and other sp. The abomasal contents were unfortunately not examined.

U50/5. Young female approximately 14 months of age. Showed similar progressive loss of condition, terminating in profuse diarrhoea for two days before death. Examination post-mortem showed areas of pulmonary congestion and collapse, petechiae on epicardium, haemorrhagic gastritis and ulceration of the large intestine. In addition the mesenteric lymph nodes were swollen and contained a quantity of thick pus. Many nematodes of *Trichuris* and other species were present. Bacteriological culture was not possible in view of the decomposed state of the viscera, but microscopic examination of sections revealed large numbers of grouped acid-fast rods in the intestinal mucosa and

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lymph nodes which morphologically were identical with *Mycobacterium johnei*. This is therefore presumed to be a case of Johne's disease.

The manner in which this young animal became infected is obscure, but presumably infection originated in the sheep running on the same pasture. No other case has been seen in either sheep or llamas.

U50/7 Female approximately two years of age. This animal was in very poor condition with swollen joints and other evidence of malnutrition. It was destroyed showing severe osteomalacia with enlarged epiphyses, softening of long bones, etc. No parasite examination was carried out.

U50/8. Adult female. Found 'down' on several occasions, final prostration, coma, death. General condition fairly good. Perforation of true stomach with localised peritonitis. Mild enteritis and swelling of mesenteric glands. Verminous bronchopneumonia. Parasites recovered from stomach and intestine:-
3500 *Ostertagia* sp., 4500 *Trichostrongylus axei*, 17 *Trichuris* sp.

U50/12. Adult male 'Bobby'. Progressive loss of condition prostration, coma, death. Condition thin, ulceration of abomasum, congestion of intestine. No helminth recovered. No bacterial disease found. Excessive sexual activity and an insufficient diet may have been responsible for death.

U50/14. New born. Died a few hours after birth, the two young
The young llamas remaining were removed to yards and have since thriven. The two adult females remaining have

retained their condition since the death of the male and the consequent freedom from the strain of pregnancy.

FAMILY SUIDAE and FAMILY TAYASSUIDAE

The former family includes the swine and the latter the Peccaries, but in view of the small numbers of these species kept they can be considered together.

Period 1938-49

The Cardiovascular System

Among the small number of reports concerning this family, two refer to 'pericarditis,' in a Wart Hog (*Phacoerus aethiopicus*) and in a Piglet (*Sus* ?) which was suspected of having a deficiency of vitamin A and also showed hepatic necrosis.

The Respiratory System

One River Hog (*Potamochoerus porcus*) is reported as showing 'double pneumonia.'

The Alimentary System

Enteritis is reported in two Pigs, in one of which it was associated with peritonitis, and also in a Peccary (?) and a Bush Pig (*Potamochoerus koiropotamus*) which showed some hepatic fatty change. 'Cirrhosis of the liver' is reported in a Wart Hog.

Tuberculosis

This disease was reported affecting a Wart Hog, where it is described as 'generalised' and a River Hog showing tuberculous meningitis, peridarditis and pleurisy.

Period 1950-51

Two deaths only occurred among the small number of swine kept.

U50/4. A male Wart Hog about two years of age. This animal went off its food and remained hidden among the straw for three days. On post-mortem examination impaction and rupture of both small and large intestines with dry food material was found leading to a subsequent peritonitis. This condition was probably due to the animal's disinclination to eat moist food.

U50/2. Nine years old male Wild Boar (*Sus scrofa*). This animal was destroyed when posterior paralysis developed after progressive loss of condition. Post-mortem examination showed slight endocarditis and multiple adenocarcinomata of the intestine with spread to the mesenteric lymph nodes.

CLINICAL NOTES

Conditions affecting the Feet

A pair of young adult Four-horned Sheep arrived in 1951. The female showed evidence of 'Foot-rot', the hooves of the four feet being distorted and the horn softened, although no discharge was observed. Paring away the diseased horn and immersion of each foot for ten seconds in 10 per cent 'Formalin' solution weekly for five weeks appeared to result in complete recovery. 'Formalin' solution has also been employed as a dressing for the Elephant's feet when they become softened.

A young Père David's Stag (*Elaphurus davidianus*) was very excitable on arrival and when placed in a concreted yard wore away the horny soles of its 'hooves' and became extremely lame.

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Recovery was rapid without treatment when the animal was given access to a grass paddock.

An old Donkey also caused itself to become lame by scraping its fore-hooves against the low wall surrounding its paddock in order to attract food from the visitors.

Overgrowth of the hooves is not uncommon in Donkeys, Antelope and Sheep even when they are kept in concrete yards, but has rarely been seen in Cattle and Deer.

Bruising in the region of the 'fetlock' has caused lameness on several occasions in Bison, but because of the intractable nature of these animals, no treatment apart from hosing with cold water has been possible. Recovery has fortunately been straightforward.

Injuries

Apart from fighting among the rams and new-born Barbary Sheep killed by the adults, these have been few. One interesting case in a young Nigerian Goat was partial paralysis of the fore limbs due no doubt to a buffet by the old male. The kid ceased to use its forelegs except when standing still, progressing by means of kangaroo-like hops. Infra-red irradiation, massage and rest permitted recovery in about three weeks.

Suspected Mineral Deficiency

Reference is made elsewhere to the destruction of an adult female Nigerian Goat because of distortion of the forelimbs. This animal had previously shown collapse and partial paralysis shortly after the birth of two kids. Calcium borogluconate by injection and calcium diphosphate by mouth resulted in apparent recovery until the symptoms leading to destruction developed.

Calcium borogluconate injections also appeared to have a beneficial effect in the case of a Harnessed Antelope, which showed sudden convulsions of an epileptiform type. A sedative dose of 'Nembutal' (Abbot) was given intra-venously at the same time, and the convulsions have not recurred for two weeks to date. Calcium diphosphate is being given in the diet.

Parasitic Disease

Dosage for the worms of gastro-enteritis type was carried out with phenothiazine in Nigerian Goats, using 12 grammes for the adults and 5 grammes for the kids. In Nigerian Sheep 15 grammes for the adults and 10 for the older lambs were given in 1950. In 1951 when the animals were in poor condition and showed, an egg count of 3,300 per gramme faeces of Strongyles, 10 grammes doses only were used. Fifteen grammes was given to the Four-horned Sheep which showed an egg count of 1000 Strongyles and strongyloides per gramme of faeces.

Reports of 35 faecal examinations for parasites are available for the two periods. 26 of these were positive, concerning 9 Lamas, 5 Sheep, 3 Goats, 2 Camels, 1 Giraffe, 1 Oryx, 1 Bison, 1 Pigmy Hippopotamus, 1 Donkey, 1 Zebra and 1 Pony.

All these reports, excepting those concerning the Pigmy Hippopotamus (*Choetopsis liberiensis*) and one Lama, referred to the presence of "Strongyle" eggs, and in addition eggs of the following parasites are reported.

Strongyloides sp. in the Giraffe and 3 Sheep

Trichuris sp. in the Giraffe, 5 Lamas, 2 Camels and
one Goat

Ascaris sp. in the Zebra

Muellarius capillarius in a Goat
Nematodirus sp. in a Soay Sheep

The Hippopotamus faeces contained eggs resembling cestodes of the Anaplocephala and Hymenolepis type, and the Lama showed Trichostrongyle infestation.

Conditions affecting the Eye

'Muffin,' a three months old Donkey Foal showed a small corneal ulceration due probably to trauma. Healing was rapid and complete using 'Albucid' (British Scheering) and Penicillin ointments morning and night respectively, leaving only a minute scar which appears to be permanent.

Similar treatment over a protracted period completely cured severe corneal ulceration in 'Boac' a young Pigmy Hippopotamus. (This case was also seen and advised upon by the clinical staff of the Royal (Dick) Veterinary College.)

Other Conditions

1. A young male Black Rhinoceros (*Rhinoceros bicornis*) was seen to discharge a small quantity of thick, apparently mucoid pus from the nostrils on arrival. This disappeared but the animal was sluggish and sleepy compared to its companion, which arrived at the same time and was presumed to be affected with sinusitis. On 1st March, 1952, the discharge recommenced and haemolytic streptococci were cultured from a sample.

Eucalyptus oil was sprinkled on the straw and a steam kettle containing "Friar's Balsam" was employed. On 3rd March, 1952, much discharge was evident and the animal appeared much more lively. The discharge continued for a few days and then ceased. No discharge has since been seen from the nostrils except on one occasion and the animal has maintained its liveliness to a moderate degree.

2. A large abscess developed in a Barking Deer at the base of the right mandible. In view of the delicate nature of the

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animal it was left untreated. The swelling ruptured, discharged and healed of itself. No recurrence had occurred one year later.

3. The aged male Dromedary developed a septic condition which affected the tissues around and beneath the sternal pad. This area was washed and dressed with Acriflavine emulsion daily until the animal became intractable, when syringing with 'Hewsol' (Hewlett & Co.) was employed. An authority on this species was consulted and he advised Stockholm tar dressings which were applied by a long stick. The condition is in a chronic state at the present.

Dehorning

The adult Red Stag is dehorned each autumn to prevent injury to the keeper and the enclosure during the rutting season. The horns are removed by sawing close to the base with a hacksaw soon after the velvet is shed.

DISCUSSION - THE UNGULATES

a) The principal point of interest arising from a study of the deaths in this order is the frequency with which parasitic disease has occurred. The general 'picture' of the parasitic gastro-enteritis and verminous pneumonia appears to have been precisely similar to that occurring in farm stock in Britain, resulting from the same faults in husbandry and caused by the same parasites with the addition of *Camelostrongylus mentulatus*.

Sheep, Lamas and Camels have been the species principally affected, only one report on a Deer mentioning heavy parasitic infestation. It is probable, however, that parasites were the cause of some of the alimentary abnormalities reported in Deer where the etiology was not stated. Cameron (1932) quotes Evan's statement that parasitic disease is the principal cause of mortality in park deer, and Whitehead (1950) has a similar opinion although his is mainly based on Cameron's article.

Most of the cases of verminous pneumonia occurred in Camels during the war years. It is understood that a number of these animals were kept together in a small grass paddock for a considerable period. Doubtless feeding was difficult at this time and the conditions appear to have been ideal for a parasitic infestation to reach pathogenic levels.

The parasitic gastro-enteritis in Sheep and Lamas during 1950 was due to a combination of overcrowding and insufficient diet. Animals of these species had been running together on the ten-acre paddock for several years and the ground had had no chance to rest at all. In addition to the other factors, the strain of gestation probably assisted in weakening the Lamas, as deaths ceased when the male died. Lamas

Lamas are reluctant to eat other food when any grass is available and probably most of the grain and roots provided was eaten by the sheep, which also showed signs of malnutrition, however. In fact it is impossible to decide whether dietary insufficiency or parasitic disease was the principal factor. Infestation with *Nematodirus* sp. has been reported in Lamas at Moscow Zoo and the seasonal variation of the faecal egg count has been discussed by Zawadowsky and Zvjagintzev (1933).

The three deaths of Nigerian Sheep associated with parasitic infestation are also of interest in that the worm burden found on post-mortem examination did not appear high enough to account for death, although it was doubtless associated with the animals' debility. These deaths were ascribed to enterotoxaemia, but it is possible that the level at which parasitic infestation becomes pathogenic is lower in these sheep than in indigenous animals. The Nigerian Goats, kept under similar conditions to the sheep, appear to be less susceptible to parasitic disease.

Parasitic disease of the above types is not frequently reported in the mortality list of other zoological collections, the majority of which do not practice the type of husbandry employed at Edinburgh. It would be interesting to know if similar parasitic disease occurs at Whipsnade Zoological Park.

Regarding the Ascarid and Strongyle infestation in the Zebra mentioned in Clinical Notes, a case is known to the writer where a number of Zebras belonging to a travelling menagerie succumbed to strongylosis when confined in a small pasture.

b) The infrequency of Neoplastic disease is of note. When the great age attained by many captive wild Ungulates is

considered, it might be expected that tumours would be found more frequently than in domestic Ungulates slaughtered for meat at an early age. References to neoplasia in this order is infrequent in the literature and it is interesting to note that one of the few cases mentioned in the London reports is intestinal papillomatosis in a Big-horned Sheep. Hamerton (1940).

c) The sporadic occurrence in this order of diseases similar to those affecting domestic stock is no doubt connected with the fact that the type of husbandry is similar. The organisms of gas-gangrene, navel ill and Johne's disease are soil borne and the diseases would not be likely to occur in 'yarded' animals.

A case of suspected 'Navel Ill' is reported by Hamerton (1938) in a Nylghiae calf, but as with parasitic disease reports are few in the literature, no doubt because of the different type of husbandry employed in other collections.

A comparable case to the Aspergillus infection occurring in a Camel is reported in an American Bison (Bison bison) by Rewell and Ainsworth (1947).

Fox (1927) reports Streptothricosis in Deer and Gazelles. It seems possible that this was Fusiformis necrophorus infection similar to that seen in a Speke's Gazelle above, and which is fairly common in domestic Ungulates.

Actinomycosis in Tapirs is also reported by Fox (1931) and streptothricosis by Ratcliffe (1942). This appears to be another confusion of terminology like that discussed under Order Marsupialia. As only small numbers of these relatively rare animals are kept in zoological collections, the incidence of some type of actinomycotic disease among them appears to be high.

- d) The comparative frequency of disease of the urinary tract is interesting as all five cases of calculus formation occurred in two species, Nylghiae and African Buffalo. Only three reports concerning Nylghiae and two concerning African Buffalo are available for study, that is, all those examined were affected.
- e) The occurrence of a small number of cases of tuberculosis in the Lama, the Oryx, the Duiker and two Pigs is not surprising. Reports of this disease in almost all species of Artiodactyla are to be seen in the literature as it is of frequent occurrence in most zoological collections. As in the other orders of mammals, tuberculosis has been remarkably rare during period 1950-51, the one case being a newly arrived animal almost certainly affected before arrival.
- f) Dystokia and diseases of the reproductive tract have been very infrequent in this group at Edinburgh, and similarly few references occur in the reports of other collections. Hamerton (1941) describes a case of dystokia in a Harnessed Antelope and a Zebra (1946).
- g) The ratio of deaths of new arrivals compared to old stock in the two orders is 13 to 16. The number of deaths among new arrivals is due partly to animals born in the park dying before the age of six months and partly to the delicate nature of antelope and some deer which are often slow to become accustomed to captivity.

ORDER XENARTHRA (EDENTATA)

Only a few Armadillos are kept at Edinburgh, being housed in heated quarters away from the public view in the winter months, and exposed in an open air, wire-fronted unheated cage of the Small Mammal House in the summer.

Period 1938-49

Of the four reports on Armadillos (? ?) one is inconclusive, one refers to prolapse of the rectum, one to catarrhal enteritis and one to herniation of the large intestine via a tear in the rectum.

Period 1950-51

The death of M50/2, a Hairy Armadillo (*Euphractus villosus*) occurred during the writer's absence. The principal finding post-mortem was reported as advanced hepatic fatty change possibly due to dietary cause.

ORDER MARSUPIALIA

There are a large number of species of 'pouched mammals', only a few of which have been kept at Edinburgh, mostly Bennet's Wallabies and Squirrel Flying Opossums.

The Wallabies occupy a small grass and rock covered paddock with an unheated house. In addition to grazing they receive some green and root vegetables and some flaked maize. Care is taken not to use oat or barley straw as bedding material. The Opossums are kept in one of the heated cages in the Reptile House behind glass and feed on chopped fruit, lettuce, mealworms and other insect food.

Period 1938-49

Seventeen reports are available for this period.

The Cardiovascular System

A Tree Kangaroo (*Dendrolagus* ?) is reported as showing calcification of the aorta.

The Respiratory System

'Double pneumonia' is reported in two Bennett's Wallabies (*Macropus ruficollis benettii*).

The Alimentary System

'Patchy gastritis' and 'enterotoxaemia' are the principal findings in two reports on Bennett's Wallabies, and ulcerative enteritis apparently of haematogenous origin in an Opossum (? ?).

'Enteritis' and 'atrophy of the spleen' are reported in a Wallaroo (*Macropus robustus*).

Dietary Disease

One Bennett's Wallaby is reported as showing a terminal pneumonia subsequent to a 'deficiency disease' and in another 'poor condition' is all that is reported.

Neoplasia

Mucoid carcinoma of the stomach with metastasis to the liver was confirmed histologically in a Bennett's Wallaby.

Special Disease

Six reports concerning Bennett's Wallabies and one Wallaroo are included here.

Four refer to "streptothricosis" affecting the stomach of the Wallaroo, the upper jaw of one Wallaby, the lungs and liver of another and the lips and cheek of a third.

The two other reports describe in one case necrosis of the bones, incisor teeth and muscle of the right maxilla, and, in the other, necrotic pharyngitis. In both cases an organism resembling *Fusiformis necrophorus* was discovered in the lesions. Inconclusive, etc.

One report of an Opossum is included here.

Period 1950-51

Seven Bennett's Wallabies and two Squirrel Flying Opossums (*Petaurus sciureus*) died during this period.

M50/1. Wallaby. Nine year old female. A slight nasal discharge was apparently seen during 1949, which disappeared.

Smears of the material showed no bacteria. The only symptoms seen were slight anorexia on day preceding death. On post-mortem examination a cervical lymph node was found to be ~~fibrinous~~, distended with creamy pus; there was a fibrinous pleurisy and pericarditis and a number of sub-capsular hepatic foci containing pus. The histological report refers to the discovery of bacteria morphologically resembling *Fusiformis necrophorus* in the pleural exudate and acid-fast bacteria resembling *Mycobacterium tuberculosis* in the

hepatic foci.

M50/3. Foetus of Wallaby. This naked creature, about eight inches long, was found dead on the ground. It is presumed to have fallen from the pouch and to have died of exposure.

M50/4. Wallaby - young adult male. This animal was found lying with laboured respiration and with severe injuries to the tail. It had presumably been set upon and attacked because of its diseased condition, for it died some hours after amputation of the last two coccygeal vertebrae was completed, showing fibrinous pericarditis and pleurisy as post-mortem findings. Histologically a number of unidentified basophillic bodies somewhat larger than staphylococci were reported, the cause of death being stated to be 'pericarditis of unknown origin.'

M51/1. Wallaby. Young adult male. No symptoms. Findings were a suppurating fistula between mandible with abscess below incisors, haemorrhagic areas in lungs, some serous fluid in abdomen, stomach full of grass and pyloric area brownish and pitted. Histological examination confirmed pulmonary congestion and aedema and chronic venous congestion of other organs. Bacteriological examination of bone marrow was negative and showed only Coliform organisms from mandible. The cause of death is not known but may have been connected with difficulty in feeding.

M51/2. Wallaby. Adult male. No symptoms. Principal findings were fibrinous peritonitis, a purulent hepatic abscess and purulent mesenteric lymphadenitis. Gram positive

and gram negative organisms seen in pus smears but coliform organisms only were cultured.

M51/4. Wallaby. Young. No symptoms. Severe injuries to head. Considered killed by adult.

M51/5. Wallaby. Adult. No symptoms. Swelling of face and throat with the appearance of bruising. Osteitis of left mandible. An organism resembling *Nocardia* sp. isolated from this area. Death probably due to attacks of adult male.

M51/ and M51/6. Two Squirrel Flying Opossums. Examination of these, one of which showed posterior paralysis for some days preceding death, was inconclusive.

DISCUSSION - THE MARSUPIALS

The principal point of interest in the small number of deaths in this order is the occurrence of Streptothricosis in the Bennett's Wallabies. This disease is well recognised in marsupials of the Kangaroo type and appears to occur wherever these animals are kept in captivity. The infection is commonly called Nocardiosis and is discussed under this name by Rewell (1948d) and Fox (1923). It is of frequent occurrence in the London and Philadelphia collections where it is reported almost annually. There appears to be some confusion over the nature of the organism involved. Goss (1942) refers to a 'kangaroo disease' apparently identical with that seen elsewhere and states the organism to be either actinobacillus or actinomyces, suggesting that it gains entry by penetration of the soft structures of the mouth by coarse food particles presumably in the same way as in the cattle disease 'lumpy jaw' and 'wooden tongue.' Fox (1924) refers to an organism called Nocardia macropodidorum, and in that an in subsequent years discusses the use of a vaccine of this organism. Osman Hill (1950), Rewell and others call the disease Nocardiosis but make no definite statement as to the nature of the organism.

In view of the similarity between those cases occurring at Edinburgh and those reported elsewhere, it seems probable that the majority of them were in fact cases of 'Nocardiosis' or 'Streptothricosis.' The organisms of this group are difficult to culture and it seems probable that a secondary infection with Fusiformis necrophorus was present in many cases, which may have been seen on examination of smears while the original streptothrix was overlooked. In one case it seems possible that there was a concurrent tuberculous infection.

Tables and histograms follow this section, illustrating the analysis carried out on the class.

Table A gives the figures for all orders of mammals during both periods, including a division of the deaths during 1950-51 into "New Arrivals," i.e., animals present in the park less than six months, and "Old Stock" arrivals present longer than that period.

Table B compares the post-mortem findings of the four principal Mammalian groups and is accompanied by a histogram.

Table C gives the total mammalian figures for Edinburgh and two histograms comparing these with Hamerton's figures for the London collection.

As stated before, each report is included under one heading only. This makes the writer's figures unsuitable for comparison with those of Fox (1923), but enables comparison to be made with those of Hamerton (1939). The total number of mammalian deaths is not very large and when divided into groups and subdivided again under the fifteen headings some of the figures are too small for comparison. Percentages have, however, been given throughout for the sake of completeness.

The Cardiovascular System

The frequency of affection of the heart and blood vessels appears to be very low considering the fact that many of the animals in a zoological collection are kept to a much greater age than those used for commercial food production. It may be that examination of this system had not always been very thorough during the first period, but despite attempts to make it so during 1950 and 1951 the figures remain low.

Hamerton (1939) gives a correspondingly low figure for London, however, and Rewell (1948c) remarks on the slight-

ness of the lesions foundⁱⁿ/the arteries even of old animals.

The figures of Fox (1923) as stated above are not readily compared, but he seems to have found abnormalities of this system fairly frequently. Fox (1935) gives a note of the conclusions arrived at in a further study of arteriosclerotic conditions in Captive Wild Animals. The most important of these conclusions are, that the disease can occur in nature, that it occurs in all species, and that it does not usually cause death.

The Respiratory System

The frequency of abnormalities of this system in the order as a whole, is much as would be expected. It is interesting to note, however, that even excluding tuberculosis, the incidence appears highest in the Primates, as these mammals are well known to be particularly susceptible to affections of the lungs. At a 99 per cent level of chance variation the difference between the Primates and the Ungulates, which order shows the smallest percentage of respiratory disease, is not significant ($20.9\% \pm 8.1 : 9.2\% \pm 6.6$) but at a 95 per cent level it is ($20.9\% \pm 5.4 : 9.2\% \pm 4.4$).

The fact that most of the Primates and many of the Carnivores are tropical animals, whereas most of the Ungulates kept are natives of a temperate climate, may account for some difference in susceptibility to respiratory affections in this collection. The tropical rodents are mostly housed in a heated atmosphere and so would not be subjected to the same danger of chilling.

Hamerton's total figure for the mammals in the London collection (Table C) is very similar to the writer's

16.3 : 13.2.

The Alimentary System

Abnormalities of this system, excluding parasitic disease, appear as the principal post-mortem finding in nearly a quarter (22.7 per cent) of all mammalian examinations. Some of the abnormalities of the tract proper were due to mechanical causes and in other cases pathogenic organisms were isolated from the tract, but in the majority of cases the etiology was not known. It seems probable that at least a few of the diagnoses were merely based on macroscopic evidence which might lead to confusion in some species, and in the second period true enteritis has not been seen very frequently.

Both Hamerton and Rewell (1947) and Rewell (1948) comment upon the difficulty of tracing the causal factor in enteritis in captive wild animals. Hamerton considers it due to the rapid growth of saprophytic organisms. Rewell found no causal organism in the majority of cases and suggests that dietary factors are probably responsible for many of them.

That dietary factors are responsible for a number of the cases of hepatic 'degeneration' included under this heading is probable. In fact a number may have been merely physiological changes such as that seen in hibernating animals by Rewell (1948c).

The feeding of unsuitable food by the visitors is another definite source of digestive disturbances, in the Primates and the Ungulates particularly.

In other cases unrecognised parasites may have been the causal agent.

Comparing the four main groups at Edinburgh, only the Rodents appear to differ greatly with regard to alimentary abnormalities. The difference from Primates and Carnivores is

significant at a 95 per cent level. ($15.7\% \pm 4.9$: $27.7\% \pm 5.9$) and is as stated elsewhere, probably due to the difficulty of recognising lesions in these small species. Freedom from casual feeding by the visitors, and the ability to subsist on a widely varied diet may also be partly responsible.

When Hamerton's figures for alimentary, hepatic and pancreatic disease are summated they give a much lower total than the writer's (12.5% : 22.7%). The reason for this may be a different emphasis placed on post-mortem findings by the pathologists concerned, or to some other factor. It is possible that in the large groups of animals kept at London a sick animal may be killed by its companions before the disease has progressed far enough to be evident on post-mortem examination, more frequently than occurs at Edinburgh. Undetected parasitism would be blamed for the higher incidence at Edinburgh were it not for the fact that the figures for Primates and Carnivores are as high as for the Ungulates.

Gastric ulceration has been discussed under the Carnivores.

Fox (1923) found disease of the gastro-entero-colitis group alone in 32 per cent of all mammals examined (1648) although his figures include all cases whether principal finding or not. The level was about 25 per cent in the Primates, Rodents and Ungulates and 46 per cent in the Carnivores. This last figure seems to be extremely high and perhaps an inflammatory origin had been on occasion attributed to the normal physiological congestion seen in the alimentary mucosa of some carnivores.

The Urinary System

Abnormalities of this system have appeared as the principal finding in only 3.3 per cent of the mammals examined during the two periods. Table B shows that the Carnivores and the Ungulates have a higher percentage than the Primates and Rodents, though the difference is not statistically significant.

The infrequency of chronic interstitial nephritis in carnivores and the frequency of calculus formation in the Ungulates has been discussed already.

Fox (1923) found the Carnivores to be the most commonly affected with disease of this system, and he states that "renal and pelvic calculi occur almost exclusively in herbivorous animals." He also found the highest incidence of glomerular, as distinct from tubular, change in the kidneys of Rodents.

Among domestic animals, Gaiger and Davies (1946) state that calculi are most commonly found in the urinary tract of dogs, cats and horses, and suggest that this is because these are kept to a greater age than other species. This reasoning does not apply in a zoological collection however. Fox (1926) reports the first case of nephrolithiasis seen in a Primate at Philadelphia and states that "calculi occur in the kidneys of the lower animals chiefly in varieties that have a single pyramid and are herbivorous."

Rewell (1948c) remarks that acute nephritis as it occurs in man does not seem to occur in animals.

An insufficient number of cases of kidney disease have occurred among mammals at Edinburgh on which to base conclusions, but it is interesting to note the few reports of glomerular involvement, two of the three cases being Primates.

No aplastic kidney conditions have been seen or reported in the mammals. Fox (1923) who similarly found them infrequent at Philadelphia, suggests that the aplasias occurring in domestic animals are perhaps the result of cross-breeding or other strains of domestication. It appears to the writer that the number of any one species of animal examined is too small to base a judgement upon, as these conditions are very uncommon even in domestic animals.

Hamerton's figure for London is not significantly lower than the writer's:- 2.1% : 3.3%.

The Reproductive System

Here again the figure appears very low, even when findings not primarily concerned with death are taken into consideration. In addition, the number of cases of dystokia that have been seen have been few. The reason for this low figure may in part be due to lack of careful inspection of the reproductive tract when examining post-mortem, but it does seem possible that the infrequency is in part due to the absence of the strains of domestication.

Only one case of mastitis has been recorded on post-mortem examination and that in a Dingo. One case in a donkey is included under Clinical Notes.

As stated in the Ungulate discussion, few references are made to dystokia in the literature, and in fact references to any genital abnormalities appear infrequent.

Hamerton's figure for the London collection is even lower than the writer's (0.9% : 1.4%).

The Nervous System

Such remarks as are apposite have been made in the discussion on the Primates, no cases whatever having been recorded in the other orders. Doubtless a few must have occurred and been overlooked, but Hamerton's figure of 1.0 per cent (Table C) endorses the idea that nervous diseases are very uncommon.

Corson-White, in Fox's report for 1927, discusses degenerative conditions in the spinal tract of two Deer and three Elk dying at the Philadelphia garden during the preceding four years, in addition to one case in a Drill. The etiology was unknown but all showed gastro-enteritis. Fox (1925) also mentions a case in a Black Bear dying from other causes.

It may perhaps be permissible here to quote Hamerton (1936) who stated of Nervous Disease in general in Wild Animals: "Etiology unknown, pathology obscure, prophylaxis impossible, diagnosis difficult, prognosis hopeless, treatment nil."

Dietary Diseases

As stated several times above it is probable that dietary factors play a far more important part than is actually shown by the figures. However it will be seen from Table C that a summation of the two columns makes Dietary Factors of one kind or another account for about 10 per cent of all mammalian deaths. Examining the figures for the individual orders it is evident that Primates and Carnivores together account for nearly all these deficiencies resulting in bone disease. As explained above, the Primate cases are almost all platyrrhine or New World monkeys and the low figure for 1950-51 is due to the fact that the stocks of these species of that group have not

been replaced since the war. Hamerton (1939) places this group at the head of his list of rachitis and osteomalacia cases.

The reason for the frequency of these conditions in carnivores is probably connected with the means of capture, again as stated above. Hamerton also places this order second to the Primates.

The Rodents show a lower incidence of disease due to both types of dietary deficiency. It would seem probable that the members of this order, like the Common Rat, have a natural ability to thrive on almost any diet. Possibly the habit of coprophagia (pseudo-rumination) occurs among some species as it does in the rabbit, and has some bearing on this point. The high figure for the Ungulates has been discussed elsewhere in relation to parasitic gastro-enteritis.

Hamerton's total figure of 10.8 per cent, obtained by adding together his 'Nutrition and Metabolic Disease' column and his 'Inanition and Marasmus' column, is quite similar to the writer's figure of 9.6 per cent.

In general it is felt that it is not specialised problems concerning the unusual diets of foreign species that have caused the majority of the deaths classified here, but ordinary faults of management. Some specialised problems do occur, e.g. the Aard Wolf, and many undetected deficiencies may, of course, exist.

Rewell (1948e) comments on the difficulty of diagnosing such deficiencies in view of the little knowledge available.

Fox (1935) considered dietary diseases of one form or another responsible for up to 25 per cent of all Primate deaths and 15 per cent of all Carnivore deaths during a ten-

year period at Philadelphia. It is presumed that the practice of keeping Ungulates in yards and hand feeding them is employed in that collection, and this would account for a lower level of dietary disease in that group.

Parasitic Disease

Animal parasites obviously play a part of considerable importance in causing disease in the mammals at Edinburgh. It has previously been explained that the reason for the high figure in Ungulates (significantly higher at a 95 per cent level than all the other orders and almost so at a 99 per cent level) is the prevalence of parasitic gastro-enteritis and verminous pneumonia under conditions of bad husbandry.

The figure for carnivores is weighted by the group of wild cat kittens affected with roundworms and hence is perhaps not a truly representative one.

The fifteen reports making up the Rodent total are also a heterogeneous collection of ecto- and endoparasitic conditions and cannot be said to serve as any real indication of susceptibility. The occurrence of several cases of "mange" is worthy of note, however, as this is a most uncommon condition in this collection, even among new arrivals. In fact, the number of ectoparasites of any kind encountered both in reports and on clinical and post-mortem examination has been practically negligible. Coupled with this may be the apparent infrequency of cestode infestation in the carnivora.

Hamerton's figure, shown in Table C, for fatal parasitic infestations is less than one-third of the writer's, which is partly explained by the different type of husbandry employed for Ungulates.

Weidman (Fox, 1923) gives figures for the level of infestation of all the families and orders, but does not quote the number of fatal infestations. He found Carnivores, and Rodents both to be affected about equally (16.9 per cent and 16.0 per cent), then Ungulates (12 per cent) and lastly Primates (9 per cent). The types of husbandry employed at Philadelphia for Ungulates may again account for the low level of parasitism. in that order.

Perhaps the principal feature ~~in that order~~ of interest in the analysis of parasitic condition at Edinburgh have been the way in which the pathological parasitic infestations of the foreign animals, with the exception of hookworm disease in the carnivores, has followed very closely the pattern of indigenous stock, that is, the close relationship between parasitism and environment.

Few examinations for blood parasites have been carried out during the period 1950-51 because of lack of time, although it is recognised that a routine examination of the blood would be desirable in every case. Rewell (1948e) discusses their somewhat infrequent occurrence in the London collection where they do not appear to have caused death on many occasions. ^{and Worth} Ratcliffe (~~1951b~~) describes 14 cases of fatal Toxoplasmosis in mammals during a ten year period at Philadelphia, that is, less than 1 per cent of all deaths.

Neoplasia

The figures given in Table B for the four main groups of mammals are small and are not significantly different statistically, although the Carnivores and the Rodents do appear to have a considerably higher incidence of tumours than the Primates and Ungulates.

These figures include all neoplastic conditions seen or reported, not merely the fatal ones, as stated in the Introduction.

Fox (1923) found a similar incidence at Philadelphia, Rodents and Carnivores being considerably more frequently affected than Primates and Ungulates, this total figure for all mammalian orders being in the region of 3 per cent.

Ratcliffe (1932b), using Fox's figures and additional material, gives the following percentages which are compared with the writer's below.

<u>Philadelphia</u>		<u>Edinburgh</u>	
0.82% of 971 autopsies	<u>Primates</u>	1.3% of 225 autopsies	
4.32% of 763 "	<u>Carnivores</u>	4.8% of 231 "	
5.56% of 431 "	<u>Rodents</u>	4.5% of 224 "	
1.84% of 598 * "	<u>Ungulates</u>	1.7% of 172 "	
2.95% of 3014 "	<u>Total Mammals</u>	2.9% of 986 "	

* Artiodactyla only.

These figures are obviously very similar.

Ratcliffe goes on to say that in general the differences in incidence between the mammalian orders can be related to the longevity of the species concerned, although he suggests that in the case of the families Mustelidae, Cervidae and Cebidae there may be some natural resistance to neoplasia.

Although no figures comparable to Ratcliffe's are available for Edinburgh concerning the relative longevity of the species in captivity, it is felt that while early death may account for the low level of neoplastic disease in the primates here, it does not do so for that in the Ungulates. Insufficient numbers have been examined to make any estimate of familial susceptibility, except for the Myocasteridae which have been

discussed already.

Hamerton (1939), Table C, gives a figure of only 1.4 per cent for "tumours and cysts" in mammals, but this may include only those considered responsible for death.

Exact estimation of the incidence of neoplasms in domesticated animals is impossible because of the difficulty of obtaining a representative sample of the population for study. Such figures as are available for study do, however, indicate a higher incidence in Carnivores than in Ungulates. Feldman (1932) suggests that tumours are rare in Horses, Sheep, Goats and Pigs and somewhat more common in Cattle, while for Dogs he gives a figure of 8-10 per cent, and Cats 5-6 per cent. Sticker (1902) found a much greater frequency in Dogs attending his clinic for treatment than in Horses and Cattle.

Willis (1948), commenting on Rodent tumours, mentions their rarity in Guinea Pigs as compared to Rats and Mice, where they are frequent.

Tuberculosis

The incidence of this disease at Edinburgh has been low in the mammals as a whole and even in the Primates has been much lower than it appears to be in other collections. The Primates have been discussed above, but it is probable that the reason for the infrequency of tuberculosis is the same for all the orders, that is, that the majority of the new arrivals at Edinburgh are given by friends of the Society abroad and do not pass through the dealers' yards and other places where they might become infected. Once established in the collection, the open air type of husbandry used for many animals must reduce the danger of infection.

Fox (1923) gives a total figure for mammals of 17 per

cent of 1648 autopsies, Carnivores and Rodents being infrequently affected (3 per cent), Ungulates frequently (9 per cent) and Primates very frequently (37 per cent).

Hamerton (1939) Table C, gives a very much lower figure than that at Philadelphia, but still nearly twice that at Edinburgh (3.8% : 1.9%). He does not give percentages, but found the families Bovidae, Cervidae, Catarrhini and Platyrrhini most frequently affected. His explanation of this distribution rests mainly upon faulty housing.

Rewell (1948c) in a discussion comparing tuberculous lesions in man and animals, states that the incidence of tuberculosis increases with the duration of captivity. This implies that infection takes place most commonly after arrival, in the London collection at least, perhaps because the animals are housed close together there and are also very readily accessible to infection from the visitors.

Special Disease

The cases falling under this rather loose term of classification have been discussed in the individual orders.

In general surprisingly few infectious diseases have occurred in the mammals and such as have been seen have been limited in their extent. Rewell (1948e) comments on the infrequency of diseases of tropical origin in the London collection. He says that, even considering the change in environment, the fact that most diseased animals probably die before arrival and the absence of the usual vectors: "it still seems curious that some conditions, common enough in the wild, should not be found in captivity." There have been many outbreaks of infectious disease of British origin reported at London, however. Canine distemper, Feline enteritis,

'Hard Pad' disease (Pseudo-distemper) and others have been referred to above and Hamerton (1941 and 1943) reports Anthrax as responsible for the death of Elephants and many Carnivores. Reference has also been made to outbreaks of similar diseases in other collections and Fox (1923), reports Rabies in Deer in the Philadelphia collection.

In comparison with other zoological collections, therefore, Edinburgh appears to have been very fortunate in this respect. It seems probable that the principal reasons are the 'open-air' type of housing employed, the practice of keeping animals in pairs or very small groups, and the fact that the gardens are situated some distance from the more populous part of the city and hence are less frequently entered by stray dogs and cats which might be carrying infection.

The susceptibility of Wallabies and Kangaroos to 'Nocardiasis' appears to be world wide, and to a lesser extent Tapirs apparently show a somewhat similar tendency to actinomycotic infection.

Hamerton, Table C, devotes a column to Mycosis, finding a 0.4 per cent incidence. One case only occurred at Edinburgh during the two periods.

Violence

The significantly higher percentage of deaths due to violence among the Rodents has already been discussed.

Very few reports exist for the period 1938-49, concern young animals killed at birth and presumably these were not submitted for examination. This may in part account for the low total of mammalian deaths due to violence at Edinburgh compared to Hamerton's figure for London, shown in Table C, (12.2% : 21.1%). The animals are kept in somewhat larger

groups and smaller enclosures at London, however, and this will probably increase the likelihood of a sick animal being killed by its companions before it shows symptoms and also increase the frequency of pre-mating battles between males.

Another cause of fighting among animals is due to "social rank" as discussed by Hediger (1950), any disturbance of which, by the introduction of new stock or the death of a member of the group, will lead to fighting. Ratcliffe (1950) states that the most frequent source of injury among captive wild animals is conflict. "As the dominant one ages, or as the younger members mature, conflict is inevitable."

Death from 'shock' due to relatively minor stress, such as that suspected in several antelope described above, is discussed in a recent paper by Christian and Ratcliffe (1952). They describe the deaths of a number of small carnivores which were associated with such slight disturbances as the noise of building operations nearby, or transfer to another cage. Their conclusion is, in brief, that a high level of diet coupled with insufficient exercise may lead to a degree of atrophy of the adrenal cortex and thus in times of severe stress to death from hypoglycaemia. Hediger frequently urges the use of training methods in zoological gardens to give certain classes of animals a sufficiency of exercise.

Inconclusive, Etc.

There is little to be said about the cases classified here. It seems probable that in a number of them dietary factors were concerned, and, particularly among the Rodents, factors of temperature.

Hamerton's figure for London is only 5.2 per cent,

compared to 12.3 per cent at Edinburgh, but in addition 16 per cent of the mortalities at London are merely classed as 'killed by order' and so for comparison in Table C they have been included together.

New Arrivals : Old Stock

101 of the former died during period II compared to 81 of the latter. The high figure for new arrivals is, in part, due to young animals killed at birth by the adults.

TABLE A.

ANALYSIS OF DEATHS IN THE MAMMALIAN ORDERS

MAMMALIA.

ORDER	PRIMATES.				LIPOTYPHA	CHIROPTERA.	CARNIVORA.				PINNIPEDIA.				RODENTIA.				LAGOMORPHA.		PROBOSCIDEA	PERISSODACTYLA				ARTIODACTYLA.				XENARTHRA	MARSUPIALIA.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
	P ₁		P ₂				P ₁	P ₂	P ₁	P ₂	P ₁	P ₂	P ₁	P ₂	P ₁	P ₂	P ₁	P ₂	P ₁	P ₂		P ₁	P ₂	P ₁	P ₂	P ₁	P ₂	P ₁	P ₂		P ₁	P ₂																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
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* P₁. 1938-49
P₂ 1950-51
N.A. Mammal in the park less than 6 months.
O.S. " " " more " " "

TABLE B.COMPARISON OF THE FOUR PRINCIPAL MAMMALIAN GROUPS.

	PRIMATES		1. CARNIVORES		2. RODENTS		3. UNGULATES	
	No.	%	No.	%	No.	%	No.	%
CARDIOVASCULAR SYSTEM.	4	1.8	3	1.3	4	1.8	7	4.0
RESPIRATORY SYSTEM.	47	20.9	36	15.6	23	10.3	16	9.2
ALIMENTARY SYSTEM.	63	28.0	64	27.7	35	15.7	46	27.2
URINARY SYSTEM.	6	2.7	12	5.2	5	2.2	8	4.6
REPRODUCTIVE SYSTEM.	4	1.8	4	1.7	5	2.2	0	-
NERVOUS SYSTEM.	3	1.3	0	-	0	-	0	-
OTHER TISSUES.	5	2.2	4	1.7	2	0.9	0	-
DIETARY DISEASE AFF. THE SKELETON.	16	7.1	13	5.6	2	0.9	4	2.3
OTHER DIETARY DISEASES.	18	8.0	19	8.2	5	2.2	14	8.1
PARASITIC DISEASE.	5	2.2	12	5.2	15	6.7	33	19.1
NEOPLASIA.	3	1.3	11	4.8	10	4.5	3	1.7
TUBERCULOSIS.	9	4.0	4	1.7	0	-	6	3.5
SPECIAL DISEASES.	4	1.8	11	4.8	17	7.6	11	6.4
VIOLENCE.	15	6.7	19	8.2	54	24.1	15	8.7
INCONCLUSIVE ETC.	23	10.2	19	8.2	47	21.4	9	5.3
TOTALS.	225	100%	231	100%	224	100%	172	100%

1. Carnivora + Pinnepedia.
2. Excluding Lagomorpha.
3. Perissodactyla + Artiodactyla.

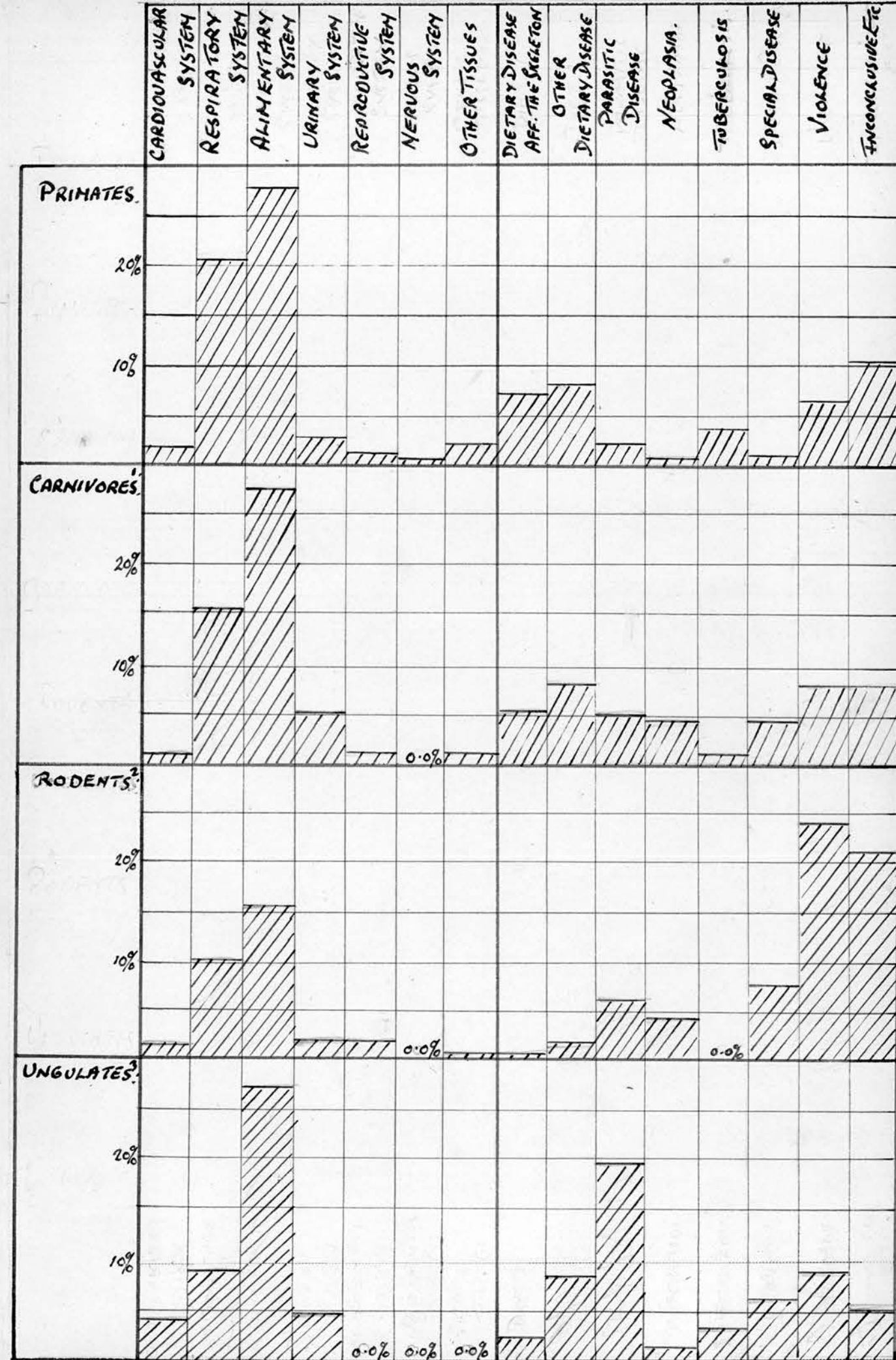
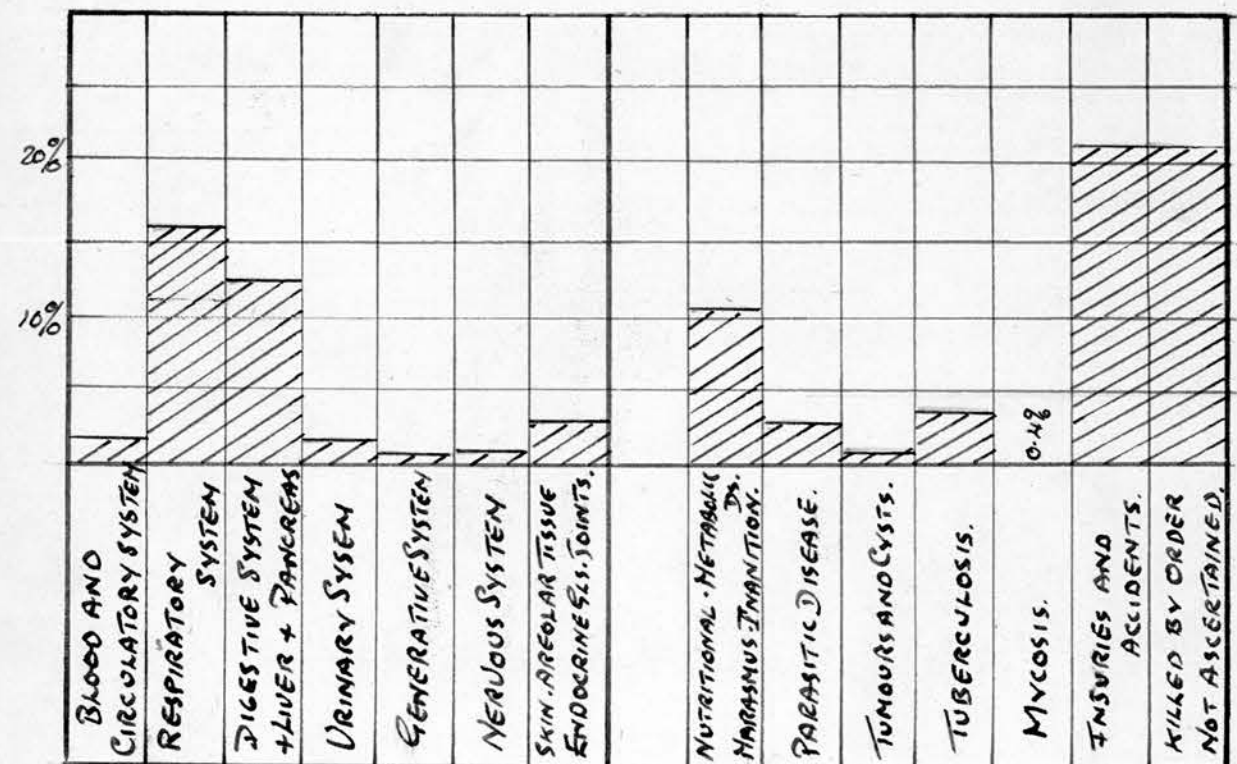
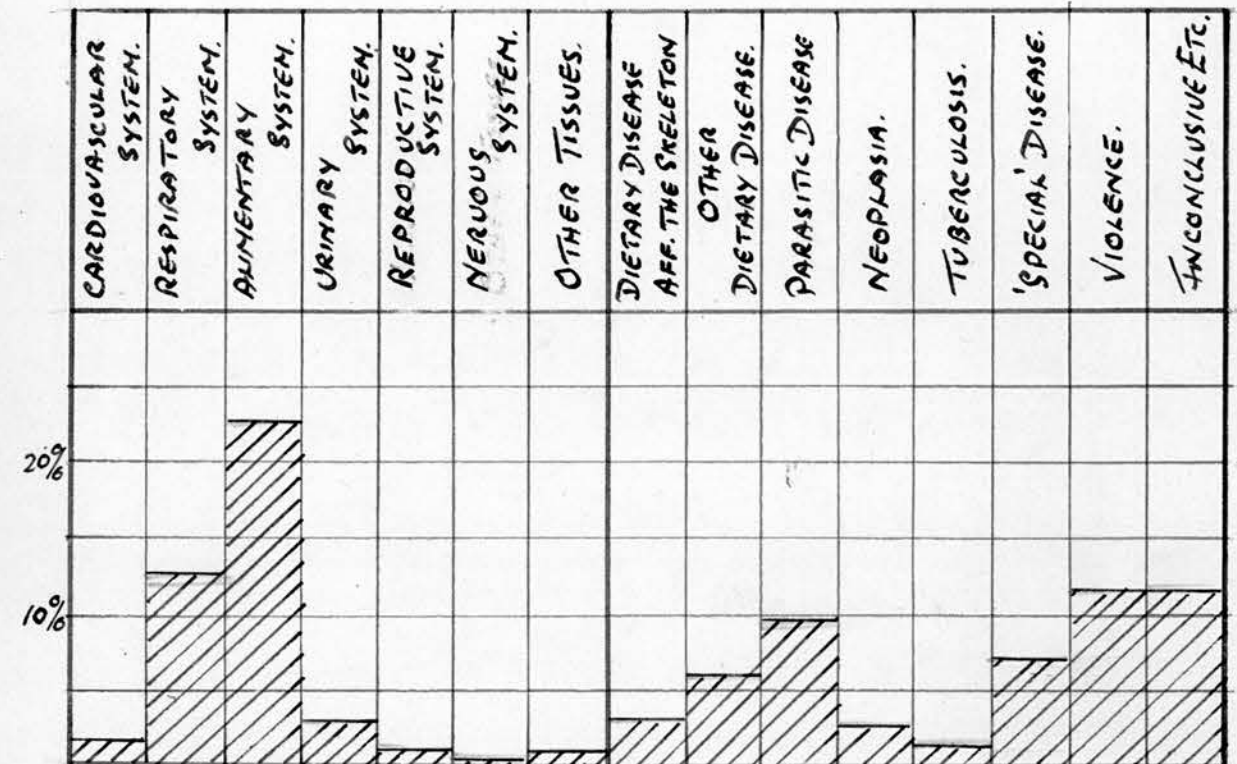


TABLE C.TOTAL MAMMALS. COMPARISON WITH LONDON.

	TOTAL PERIOD I.	NEW ARRIVALS PERIOD II #	OLD STOCK PERIOD II #	TOTAL PERIOD II.	TOTAL.	PERCENTAGE.
CARDIOVASCULAR SYSTEM	15	1	4	5	20	2.0
RESPIRATORY SYSTEM.	107	14	6	23	130	13.2
ALIMENTARY SYSTEM.	197	10	12	29	224	22.7
URINARY SYSTEM.	32	.	.	1	33	3.3
REPRODUCTIVE SYSTEM.	12	.	1	2	14	1.4
NERVOUS SYSTEM	3	.	.	.	3	0.3
OTHER TISSUES.	11	.	.	.	11	1.1
DIETARY DISEASE AFF THE SKELETON.	28	2	5	.	35	3.5
OTHER DIETARY DISEASE.	55	3	2	.	60	6.1
PARASITIC DISEASE.	82	5	9	15	97	9.8
NEOPLASIA.	26	.	3	3	29	2.9
TUBERCULOSIS.	18	1	.	1	19	1.9
'SPECIAL' DISEASE.	54	4	9	16	70	7.1
VIOLENCE.	45	45	16	75	120	12.2
INCONCLUSIVE ETC.	75	16	14	46	121	12.3
TOTAL.	760	101	81	226	986	100%

* Excluding lagomorpha.

EDINBURGH



LONDON

Drawn from the figures of Hamerton (1939)

SECTION B - CLASS AVES

Because of the large number of orders into which this Class is divided, only in a few are there a sufficient number of post-mortem reports and examinations to make analysis worthwhile. In addition, there is considerably less difference between the birds of the avian orders than between the animals of the mammalian orders. For these reasons no discussion is given after the individual orders, points of difference between the orders with a sufficient number of autopsies being included in the main discussion at the end of the Section.

In general, the post-mortem reports concerning birds contain rather less information than those concerning mammals and in many cases only one finding is stated. In view of the number of reports to be analysed and the inconclusive nature of many, they have been dealt with in rather less individual detail than the mammalian reports. Reference to secondary findings is made when these are of particular interest but note is not always included of negative bacteriological examination.

In many cases the common names of the birds given in the reports do not allow an estimation even of the genus to be made and in these cases the symbol (? ?), used in the mammals, has been omitted.

A short description of the type of housing used has been given at the beginning of each order. To avoid repetition, however, it can be stated here that large numbers of wild birds inhabit the park and the practice of pinioning or clipping the larger birds and keeping them in paddocks without roofs, allows free contact between the captive and the free-flying species.

ORDER PASSERIFORMES

This order includes most of the Finches or singing and perching birds. They are mainly graminivorous and consequently ^{is} their food/easily supplied in captivity. The majority in the zoological collections are tropical in origin and at Edinburgh are kept in a heated house with access to outdoor cages during warm days. The indigenous species such as Ravens and Crows are kept in outside aviaries.

Period 1938-49

The Cardiovascular System

The only report included here concerns a Myna showing chronic passive congestion of the viscera and suspected of dying of heart failure.

The Respiratory System

Twenty-seven of these 30 reports state the principal finding to be pulmonary congestion. The 7 reports mentioning other diagnoses are:-

Raven (*Corvus corax*) - Inhalation of ingesta.

Mannakin (*Spermestes* ?) - Pneumonia

Raven - Pneumonia of bacterial origin.

Silverbill (*Euodice cantans*) - Pulmonary congestion
due to streptococcal infection.

Waxbill - Pneumonia due to a multiple infection.

Black Tanager - Catarrhal rhinitis.

Bird of Paradise - Pneumonia?

It is interesting to note that no indigenous passerines are mentioned as dying from congestion of the lungs.

The Alimentary System

Of the 15 reports included here 7 concern the alimentary tract proper and 8 the liver.

The Stomach and Intestines

Impaction of the gizzard is reported in a Rook (*Corvus frugilegus*) and perforation of the intestine in a Glossy Starling. Five reports refer to enteritis, in one case a haemolytic micrococcus being recovered.

The Liver

Eight reports are included here.

'Fatty liver' in a Canary (*Serinus canarius*).

Hepatitis and peritonitis in a Canary.

Chronic caseating hepatitis in a Tanager.

'Enlarged liver' in a Canary.

Hepatitis in a Crested Myna (*Ampliceps coronatus*)

only *Bacterium Coli* being isolated.

Nodular hepatitis in a Crested Myna.

Nodular hepatitis and splenitis in a Chopi Starling

(~~???~~)

'Fatty change in liver and kidneys' in a

Sparrow (*Padda oryzivora*).

The Urinary System

Two reports only included here, both of nephritis in a Crested Myna and an Indian Hill Myna (*Eulobes ?*).

The Reproductive System

Two reports of 'egg peritonitis' in a Bullfinch (*Pyrrhula ?*) and a Sayaca Tanager (*Thraupis sayaca*).

Dietary Disease

No bone diseases are reported and three birds only are included, a Masked Weaver Bird (*Sitagra luteola*), a Jackdaw (*Coloeus monedula*) and a Glossy Starling which showed cachectic changes.

Parasitic Disease

It is possible that in some of the nine cases mentioned here the parasites were not the actual cause of death, but they were the sole or principal finding mentioned in each case.

'Tapeworms' in a Magpie (*Pica pica*), two Mannakins and a White-throated Sparrow (*Zonotrichia albicollis*) also showing enteritis.

'Coccidiasis' in a Hooded Crow (*Corvus cornix*).

'Roundworm' in a Glossy Starling, a Spotted Starling (*Oriolus-oriolus*) and a Golden Oriole (*Oriolus oriolus*).

'Threadworms' in a Glossy Starling.

is made

In addition to the above mention of parasitic infestation in only one other bird in this order, i.e., *Capillaria* sp. in a Grosbeak.

Neoplasia

The sole report of a neoplasm was in the ovary of a Weaver Bird.

Tuberculosis

Generalised infection reported in a Chopi Starling and simply 'tuberculosis' in a Hill Myna.

Special Diseases

Six reports mention mycosis. In a Piping Crow (*Gymnorhina* ?), a Green Singing Finch (*Serinus mozambicus*) and a Canary it is described as respiratory mycosis; in a

Glossy Starling, a Red Breasted Marsh Bird (*Pseudoleistes* ?) and a Black and White Blackbird it is not further described.

Two Weaver Birds and a Magpie are reported as suspected generalised bacterial infections, one of the former with *Proteus* sp. and the latter with *B. coli*.

One report of pasteurellasis in a Canary, and one of Pseudotuberculosis in a Weaver Bird are also included.

Myeloid leukaemia in an Orange Headed Thrush is the only virus disease mentioned.

Violence

The small number of reports include two Jackdaws killed fighting, a Raven with a fatal septicaemia subsequent to injury, three Canaries, two Bullfinches, a Spotted Thrush and a Green Singing Finch.

Inconclusive, etc.

Of these 38 reports, two - a Yellow Hammer (*Emberiza-citrinella*) and a Raven showed some senile changes, and three stated the carcasses to be too decomposed for examination. Seven of the reports concerned Canaries.

Period 1950-51

The Respiratory System

Congestion of the lungs was seen in many examinations but it was the principal finding in 15 tropical Finches (A50/32, 69, 74, 75, 76, 130, 146, 166, A51/4, 5, 48, 76, 128, 147, 160).

In a Ribbon Finch (*Amadina fasciata*) A51/124, the lungs showed consolidation and collapse in addition to congestion.

The Alimentary System

The Crop: Impaction of the crop was the sole finding in a Waxbill A51/145.

The Intestines

Congestion of the alimentary mucosa was the principal finding in three Jackdaws A50/141, 142 and A51/197. In one of these nematode eggs were found in the intestine but not in sufficient numbers to justify a diagnosis of parasitic enteritis. A Finch A50/77 and a Three-Coloured Num (~~← ? →~~) A50/88 also showed intestinal congestion as the main finding.

The Liver

Some degree of hepatic abnormality was the principal finding in six Tropical Finches A50/70, 71, 129, 138, 152, 195, and enlargement of liver and spleen is all that is reported in another A50/153.

The Urinary System

One Non-parcel Bunting (~~← ? →~~) A51/153, which showed distension of the cloaca and ureters with urate material and a Tropical Finch A50/78, reported as showing nephritis, are included here.

The Reproductive System

Impaction of the oviduct with an incompletely calcified egg occurred in a Canary A50/63. In a Canary A50/178, a Weaver (~~← ? →~~) A50/190, and a Green Singing Finch A50/30, egg material was found in the abdominal cavity and death was ascribed to 'egg-peritonitis.'

Other Tissues

One Canary A51/167, showed a large caseous mass in the pectoral region which protruded into the thoracic cavity. Its origin could not be determined.

Special Disease

A Fire Finch A50/89 (~~Munia punctulata~~) and a Spice Finch (~~Munia punctulata~~) A50/90 are reported as showing Erythro-leucosis.

Violence

The significance of the small haemorrhages so frequently found on the surface of the cranium in small birds, particularly of this order, is not always clear. The haemorrhages are immediately beneath the periosteum, appearing as dark irregular areas on the white bone and they stand out clearly as soon as the skin is removed from the head for there is little subcutaneous tissue in this region. No swelling is usually evident and only occasionally is any damage to the bone apparent. Further remarks are included in the discussion at the end of the section on birds.

Head injuries of this type were the principal finding in a Golden Oriole A50/46, a Shama A51/123 (*Kittacincula* ?), two Whydahs A51/149 and 156, two Weaver Birds A51/57 and 142, a Canary A51/154, a Raven A51/166 and four Tropical Finches A50/128 and A51/48, 146 and 151.

Injuries were associated with pulmonary congestion in two more Tropical Finches A51/130, 133, and in a Red-cheeked Waxbill (*Estrilda melpoda*) A51/134, where a diplococcus of unknown significance was isolated from the lung tissue.

The remaining birds included here are two Magpies A50/170 and 181, killed by crows, a Bullfinch A50/48, which became entangled in the wire of its cage; a Jackdaw A51/67 killed by rats; a Ground Thrush A51/75 killed fighting; a Green Singing Finch A51/3, a Canary A51/2 and 7 Tropical Finches A50/130, 192, 193 and A51/71, 86, 125, 132.

Inconclusive, etc.

Examination of 40 Tropical Finches was inconclusive (A50/15, 42, 68, 79, 80, 81, 82, 83, 84, 85, 86, 87, 133, 149, 150, 151, 154, 155, 156, 158, 159, 160, 162, 163, 164, 165, 168,

169, 174, 175, 176, 177, 179, 180, 189, 191 and A51/1, 30, 39, 77).

Thirty-three tropical finches and one Jackdaw were not submitted for examination or were not reported upon (A50/73, A50/91-120, A51/65, 116, 121).

ORDER PICIFORMES, ORDER COCCYIFORMES, and ORDER CORACIIFORMES

The first of these orders includes the Toucans and Woodpeckers, the second the Coucals, Touracos, Plantain Eaters and Cuckoos, and the third the Hornbills, Hoopoes, Kingfishers, etc.

These three are grouped together because they are neighbouring orders in the classification used and because of the small numbers of reports on the separate orders.

The Touracos and Plantain Eaters are housed in the Tropical Bird House as described under Passeriformes. They are mainly frugivorous. The Hornbills, Kingfishers, Coucals and Woodpeckers are in outdoor aviaries and they are insectivorous and carnivorous.

Period 1938-49

The Cardiovascular System

One report only, of pericarditis in a Kingfisher.

The Respiratory System :

The three reports here are all of Touracos (Turacus ?) two showing pulmonary congestion and one oedemia of the lungs and general venous congestion.

The Alimentary System

Fifteen reports concern abnormalities of this system.

The 'Stomach': Impaction of the proventriculus is reported in a Hornbill and perforation of the gizzard in a Toucan (Rhamphastos ?).

The Intestines : Haemorrhagic enteritis is reported in two Hornbills, a Touraco and a Plantain Eater (Musophaga ?); catarrhal enteritis in a Touraco, 'non-infectious' enteritis in a Touraco, and 'Enteritis' in a Plantain Eater.

The Liver: Fatty change in the liver is reported in a

Hornbill, a Touraco and a Toucan, and rupture of the liver, cause unstated, in two other Hornbills. One report on a Laughing Jackass (*Dacelogigas*) gives chronic pancreatitis as the principal finding.

The Urinary System

Nephritis is the only abnormality mentioned, once in a Hornbill and once in a Toucan.

The Reproductive System

The one report is of a Hornbill, showing haemorrhage into the oviduct.

Dietary Disease

The only report here is of inanition in a West African Hornbill.

Neoplasia

The Plantain Eater reported here showed what appeared to be a neoplastic condition of "the stomach."

Parasitic Disease

Haemosporidial infection is referred to in seven reports concerning Touracos, on one occasion being named as *Haemoproteus*. Microfilariae were found in a Hornbill, and a Coucal (*Centropus* ?) is reported with 'parasitic enteritis.'

These nine reports are the total in which parasites are mentioned for these Orders.

Special Diseases

A Giant Kingfisher showed generalised tuberculous lesions.

Leukaemia is reported in a Touraco.

One Toucanet (*Selenidera macrirostris*) is reported as a suspected septicaemia, only coliform organisms being recovered.

157 159

Violence

Two Touracos and a Hornbill are reported as dying from fighting injuries.

Inconclusive, etc.

Four Touracos, one Hornbill, one Toucan and one Toucanet are included here.

Period 1950-51

A50/38, A51/20, Four Touracos (*Turacus persa buffoni* and 33, 84.

T. macrorhynchus) all old stock, died and were examined. Three of them showed injuries due in two cases to other birds, and in one case to rats. The fourth was destroyed because of an arthritic condition affecting the legs.

A51/83. An old Ground Hornbill (*Bucorvus cafer*) showed focal bacterial necrosis of liver and kidney. The only organisms isolated from the viscera was *Proteus mirabilis*.

A50/121. A young Cuckoo (*Cuculus canorus*) arrived in poor condition, died a few days later and was not submitted for examination.

A51/40. An old Ground Hornbill showed impaction of the proventriculus with felt-like material. In addition the kidneys appeared congested and enlarged and histological examination showed widespread degeneration of the secretory tubule epithelium. This bird was certainly suffering from kidney disease, although the proventricular impaction probably caused death.

ORDER PSITTACIFORMES

This large order contains the Parrots, Parrakeets, Cockatoos, Cockatiels, Lories, Lorikeets, Macaws, Budgerigars (Undulated Grass Parrakeets) etc. They are principally graminivorous, but some species take a little green food and fruit. Some, particularly the budgerigars, are housed in the Tropical Bird House previously described. Others are kept in outdoor conditions throughout the year, each of these cages being provided with sleeping boxes.

Period 1938-49

The Cardiovascular System

Only two reports are included here; a Yellow-fronted Amazon (*Amazona* ?) showed arteriosclerosis and also hepatic cirrhosis, and a Cockatiel (*Leptolophus hollandicus*) a dilated heart and general venous congestion.

The Respiratory System

Of the 46 reports included here, 40 mention pulmonary congestion as the principal finding. These comprise 33 Budgerigars (*Melopsittacus undulatus*), one Red-fronted Lovebird (*Agapornis* ?), one Orange-crowned Parrot, three Cockatiels, one Blossom-headed Parrakeet (*Psittacula cyanocephala*) and one Conure. In only one of these reports is reference made to a bacteriological examination, a Budgerigar where *Proteus* and Coliform organisms only were recovered.

The remaining six reports are of 'pulmonary haemorrhage' in a King Parrakeet (*Aprosmictus scapularis*), 'haemorrhagic pneumonia' in a Blue-fronted Amazon (*Amazona aestiva*), pneumonia in a Green Amazon (*Amazona* ?), a Fischer's Lovebird (*Agapornis fischeri*) and a Budgerigar from which a staphylococcus was isolated, and one 'doubtful' case in a Budgerigar.

The Alimentary System

Thirty-four reports are included here, of which 20 concern the alimentary tract proper, and 14 the liver.

The Intestines:

(a) Impactions - of the crop in a Budgerigar, of the gizzard in a Budgerigar, of the rectum in a Lesser Sulphur-crested Cockatoo (*Kakatoe sulphurea*), of the cloaca in a Budgerigar.

(b) Inflammations - 'Haemorrhagic enteritis' in a Parrot, two Lovebirds, two Blue-fronted Parrots from one of which *Pseudomonas pyocyanea* was isolated, two Rose-breasted Cockatoos (*Kakatoe* ?) and a Green Amazon Parrot.

'Acute enteritis' in a Blue and Yellow Macaw (*Ara ararauna*).

'A non-specific enteritis' in a King Parrakeet.

Enteritis due to a streptococcus in a Bauer's Parrakeet (*Barnardius zonarius*) and to a mixed infection in a Budgerigar.

'Enteritis' undescribed in a Lorikeet, a Yellow-Streaked Lorie, an Alexandrine Parrakeet (*Psittacula nipalensis*) and a Budgerigar.

The Liver:

Fatty change is reported in two Budgerigars and a Sulphur Crested Cockatoo.

'Hepatic necrosis' in a Blue and Yellow Macaw, an Amazon and a Budgerigar.

'Hepatic cirrhosis' in a Yellow-headed Amazon (*Amazona ochrocephala*) and a Blue-fronted Amazon with 'dropsey'.

'Toxic degeneration' in a Cockatoo.

'Hepatitis' in a Rose-breasted Cockatoo.

Hepatic degeneration believed to be of bacterial origin in

in two Roseate Cockatoos (*Kakatoe roseicapilla*) and two Grey Parrots (*Psittacus erithacus*).

The Urinary System

Six of the eight reports included here refer to nephritis, once with 'visceral gout.' The other two mention 'visceral gout' but not nephritis thus:-

'Visceral gout' in a Green Amazon and an African Grey Parrot.

'Visceral gout and nephritis' in an unnamed Parrot.

'Nephritis' in two Budgerigars, two Sulphur Crested Cockatoos and a Green Amazon.

The Reproductive System

All 11 reports are of Budgerigars, six with so-called 'egg-peritonitis,' three with impaction of oviduct, one with prolapse of oviduct and one with 'distension' of oviduct.

Other Tissues

One report of thyroid enlargement in a Budgerigar is included here.

Dietary Disease

One report - 'inanition' in a Budgerigar.

Parasitic Disease

Again only one report is included here, that of Haemosporidia in the blood of a Red and Blue Macaw (*Ara macao*). This is the only reference to parasite infestation in all the reports concerning the Psittaciformes, apart from external mite infestation in three Budgerigars.

Neoplasia

Four of the six reports refer to Budgerigars, one 'nephritis sarcoma,' one 'neoplasia of ovary and liver' and two undescribed 'neoplasia.'

The other two are a 'cystic ovarian tumour' in an

Alexandrine Parrakeet and a 'neoplasm of the kidney' in a Sulphur Crested Cockatoo.

Special Diseases

Mycosis is referred to three times in Amazon Parrots, as 'pneumomycosis' twice and a 'Aspergillosis' once.

Salmonella infection is referred to three times. In a Blue-fronted Parrot, ~~as~~ Salmonella typhimurium was identified, and in a Grey Parrot and an Alexandrine Parrakeet the type is not described.

Septicaemia was suspected three times, in a Greater Blue-fronted Parrot, a Rose-breasted Cockatoo and due to *S. coli* in a Budgerigar.

Violence

Nineteen reports describe injuries as the principal finding. Twelve concern Budgerigars, four Cockatoos and two Parrakeets. In addition, an Alexandrine Parrakeet with a gangrenous condition of the 'knee' joint due to infection with staphylococci is included.

Inconclusive, etc.

The 52 reports included here concern 31 Budgerigars, four Cockatoos, two Cockatiels, nine Parrots, three Parrakeets, two Lovebirds and one Macaw.

Period 1950-51

The Cardiovascular System

A51/157. Old female Blue-fronted Amazon. The principal lesion found was arteriosclerosis affecting the aorta. This vessel was firm and inelastic for a short distance after leaving the heart, the intima having a green-yellow roughened appearance. Numerous foci of infiltration with inflammatory cells were seen in the kidney substance on histological examination, possibly

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originating as thrombi from the aortic intima.

Several other psittacine birds examined showed arteriosclerotic changes of the aorta, but not as principal finding.

The Respiratory System

The one case of disease of this system was a mycotic affection included under the 'Special Disease' heading.

The Alimentary System

Congestion of the intestinal mucosa was noted in a number of examinations but abnormality of this system appeared to be principal finding only on two occasions. These were A50/137, a Budgerigar with impaction of the crop with seed, and A51/138, a newly arrived Gold-collared Macaw (*Ara auricollis*) showing duodenal inflammation and fatty and regenerative liver changes.

The Urinary System

Six birds are included here:-

- A51/131. Blue and Yellow Macaw. Resident in the park over 3 years, showed lameness and anorexia some days before death. The kidneys, which appeared swollen and 'waxy' on nakedeye examination, examined microscopically showed ~~hyaline~~ change in the centre of many glomeruli and pyknosis and karyorrhexis of the nuclei of the secretory tubular epithelium. The heart muscle showed some degree of 'brown' atrophy.
- A51/126. Sulphur Crested Cockatoo. Old stock. Deposition of uratic material on the pericardium and in joint capsules was found. The ureters were distended with the same substance and the kidneys were pallid. Histological examination showed hyaline change and vacuolation of

many glomeruli and some degeneration of tubular epithelium.

A50/50. African Grey Parrot. Over 30 years of age. Fluid and 'chalky' material found in pericardial sac. Fibrinous material seen in the airsacs. Much uratic material distending cloaca and rectum. Bacteriological examination negative. Liver and kidneys appeared abnormal on 'naked-eye' examination, but no histological examination was carried out.

A51/106. Blue-fronted Amazon Parrot. Old stock. Reported 'pasting up' of vent by excreta causing obstruction of the bowel and a resultant enteritis.

A51/25. Lovebird. Old stock. Macroscopic evidence of nephritis, but no histological examination.

A51/159. Ring-necked Parrakeet (*Psittacula manillensis*). This old male bird had been lame for a long period before death. Large deposits of uratic material were found in the joint capsules, particularly of the feet, which could be seen to be distended with the substance even before the skin was incised. Histological examination of the kidneys showed pyknosis and karyolysis of the nuclei of the epithelial cells of the secretory tubules, some of which contained casts.

The Reproductive System

In six Budgerigars abnormalities of this system were the principal finding.

A50/17 showed a broken egg within the oviduct and the ovary appeared abnormal. In A50/23 the congested oviduct appeared impacted by an over-large egg. Soft-shelled eggs were present in the oviducts of A51/2 and A51/32. 'Egg peritonitis' was apparently responsible for death in A51/53 and A50/161.

Neoplasia

In a Budgerigar, A50/21, a 'tumour' was found 'involving liver, kidney and spleen.' It was not further identified.

Tuberculosis

The only case of this disease in the Psittaci during this period was A51/63, a Great Black Cockatoo (*Probosciger aterrimus*) which was an old resident. The bird had been sluggish and feeding poorly for a long period and on examination fibrinous 'peritonitis' and intra-abdominal haemorrhage was found, the liver showing many large caseous abscesses in its substance from which acid-fast bacteria were recovered.

Special Disease

A caseating condition of the lungs was seen in a Grey Parrot, A50/136, from which a fungus growth, not typical *Aspergillus Fumigatus* was cultured.

Violence

The remarks made on head injuries among the Passeri-formes apply here as elsewhere.

Injuries from attacks by other birds were the principal finding in a Grey Parrot, A50/148, which showed intestinal congestion; a Bare-eyed Cockatoo (*Kakatoe sanguinea gymnopsis*) A50/22, which had a large egg within the oviduct; a Leadbeater's Cockatoo (*Kakatoe leadbeateri*) A50/29, two Cockatiels A50/140 and A51/122, a Rosella Parrakeet A50/188, two Blue and Yellow Macaws A51/16 and A51/40, and a Grey Parrot A50/185. So far as is known all except one Cockatiel were old stock.

Head injuries were seen in a Budgerigar A50/34 and an Orange-crowned Parrot, old stock, A51/155, ~~xxx~~ A51/143. a Red-headed Lovebird trapped itself behind a sleeping cage, a Rose-breasted Cockatoo A51/102 old stock, was killed by careless

handling and a Budgerigar A50/57 showed an injury to the breast muscle.

Inconclusive, etc.

Examination of a Budgerigar A50/37, a Sulphur -crested Cockatoo A50/125, a newly arrived Amazon A51/64, a Red-faced Lovebird A50/182, and a Black-headed Conure (Nandayus nenday) A51/47, were inconclusive.

A51/27 and A50/122 were not submitted for examination.

ORDER STRIGIFORMES

This order includes all the Owls. They are exclusively raptorial in habit and are housed in outdoor aviaries throughout the year.

The Alimentary System

The nine reports included refer to:-

Abscess of the gizzard in a Long-eared Owl (*Asio otus*).

'Atrophy of the gizzard' in a Wood Owl.

Impaction of the gizzard, pulmonary oedema in a Tawny Owl (*Strix aluco*).

Ulceration of the gizzard in an Eagle Owl (*Bubo bubo*).

Prolapse of 'bowel' in a Barn Owl (*Tyto alba*).

Haemorrhagic enteritis in a Fish Owl (*Nyctea nyctea*).

Enteritis in a Snowy Owl (*Nyctea nyctea*).

'Acute peritonitis' in an owl.

Hepatic abscess in a Barn Owl.

The Urinary System

The one report is of nephritis in a Norwegian Eagle Owl (*Bubo ?*).

Parasitic Disease

'Roundworms' are reported in an Eagle Owl with enteritis.

Special Disease

A report of 'mycosis' in an American Eagle Owl (*Bubo virginianus*), of 'leukosis' in an Eagle Owl and of a coliform septicaemia in a Tawny Owl, are of the three included here.

Violence

Injuries were the principal finding in a Fish Owl, four Barn Owls and an Eagle Owl. Also included is toxæmia from an infected wound in an Eagle Owl.

Inconclusive, etc.

Reports on two Tawny Owls, a Snowy Owl, a Short-eared

Owl (*Asio flammeus*).

Period 1950-51

Thirteen Owls were received for examination during the period. The results of examination were even less conclusive than those on birds of other orders.

A50/6. American Eagle Owl. Old stock. Reported as showing widespread nodular condition of intestinal mucosa and submucosa. No histological report received.

A50/58. Tawny Owl. Some post-mortem decomposition had occurred. Catarrhal thickening of intestine and distension of cloaca with liquid and solid excrement were found.

A51/150. Old female American Eagle Owl. This bird was somewhat decomposed when received. The beak was malformed with age and a large piece of tendinous meat was distending the 'stomach'. Presumably the bird had been unable to tear its food into small pieces. In addition the kidneys had a waxy and marbled appearance and on histological examination there was seen to be a disturbed arrangement of the epithelial cells of the secretory tubules. This was possibly an artifact as the cells themselves appeared little abnormal.

A51/90. Tawny Owl ? The only abnormality evident was 'ballooning' of the cloaca with liquid and solid uratic material. Histological section of the kidneys showed considerable degenerative changes in the renal secretory tubule epithelium.

A50/56. Snowy Owl. Old stock. This bird was grossly over fat. A broken egg was present in the oviduct and egg material was distributed over the abdominal viscera, i.e., there was an 'egg-peritonitis'.

- A50/64. Tawny Owl. New arrival. The bones were soft and pliable, but there was no other significant abnormality.
- A51/36. Barn Owl. New arrival. Died from 'inanition' when isolated for treatment of a fractured leg.
- A51/135. Tawny Owl. Arrived previous day. Destroyed because of wing injury.
- A50/27. Tawny Owl. Old stock. Malformed beak. No other abnormality seen. Possibly killed by other birds.
- A51/108. Tawny Owl. Unsuitable for examination owing to decomposition.
- A50/1. Owl. Very fat. Found dead in pool. Showed bruising of the legs. The lungs were wet and congested. Presumably it had been attacked by other birds and subsequently drowned.
- A51/127. Barn Owl. Old stock. Not received for examination.
(Carine noctua)
- A51/100. Little Owl./ New arrival. Examination was inconclusive. (~~Carine noctua~~).

ORDER ACCIPITRIFORMES

This includes all the Eagles, Hawks, Falcons, etcetera, many of which are indigenous and all of which are exclusively raptorial (Carnivorous). They are housed in outdoor, unheated cages throughout the year.

Period 1938-49

The Cardiovascular System

The one report is of a streptococcal pericarditis in a Sparrowhawk (*Accipiter nisus*).

The Respiratory System

Pulmonary congestion is reported in a Kite (*Milvus milvus*) and a Sparrowhawk, and pneumonia and 'pleurisy' in a Peregrine Falcon (*Falco peregrinus*).

The Alimentary System

Obstruction of the pharynx is reported in a Sparrowhawk. There is one reference to impaction of the gizzard and an associated enteritis in a Peregrine Falcon and one to 'atrophy' of the gizzard in the same species. (It seems probable that the investigator was comparing this with the same organ in the fowl, which is anatomically very different.)

'Enteritis' is the principal finding in reports on a Kestrel (*Falco tinnunculus*), a Peregrine Falcon and an Eagle and is described as 'mucoid' in another Kestrel and 'haemorrhage' in an Ayre's Hawk Eagle (*Hieraaetus ayresi*).

'Fibrinous occlusion' of the intestine is reported in a Vulturine Sea Eagle and 'intestinal stasis' in a Peregrine Falcon.

The Liver

'Cirrhosis' of the liver is reported in a Crested Hawk Eagle (*Stephanoaetus coronatus*) and a Griffon Vulture

(*Cyps fulvus*) in the latter being associated with ruptured mesenteric vein.

The Urinary System

There are seven reports of nephritis:-

Two Sparrowhawks, a Crowned Hawk Eagle, a Lanner (*Falco biarmicus*) a Peregrine Falcon, a Crested Serpent Eagle and a Black Vulture (*Aegyptius monachus*).

The eighth report is of lithiasis and cloacal prolapse in a Goshawk (*Astur gentilis*).

Dietary Factors

There is one reference to deficiency affecting the skeleton, 'rickets' in a Buzzard (*Buteo buteo*). The other four are of 'inanition', 'malnutrition' and similar findings in a Crested Serpent Eagle, a Black Vulture, a Peregrine and a Ger Falcon (*Falco rusticolus*).

Parasitic Disease

Two reports refer to *Filariae* in the airsacs of Peregrine Falcons.

Five mention roundworms, associated with impaction of the intestine in a West African Buzzard (*Buteo* ?), and enteritis in another, rupture of the stomach in a Buzzard and as intestinal ascariidiasis in two Sparrowhawks.

In addition to the above where parasitic infestation appears to be the principal finding, 'roundworms' are also mentioned in a Crested Hawk Eagle and 'threadworms' in a Sparrowhawk.

Tuberculosis

The nine reports mentioning this disease describe it as:-

'Generalised' in a Kestrel, a Buzzard, a Martial Hawk Eagle

(*Polemaetus bellicosus*), a Brahminy Kite (*Haliastur indus*), and a Hooded Vulture. (*Necrosyrtes monachus*).

'Intestinal' in a Buzzard.

'Of the left lung' in a Brahminy-Kite Vulture.

'Acute miliary' in a Brahminy Kite

'Mixed infection with mycosis' in a Golden Eagle (*Aquila chrysaetos*).

The majority of these deaths occurred during the years 1940-1941.

Special Disease

Four of the seven reports included here are of mycosis. A report of a mixed infection with tuberculosis is included under the preceding heading. It is described as pneumomycosis in a Golden Eagle and a Crowned Hawk Eagle, as 'septicaemia and mycosis' in a Golden Eagle, and just as mycosis in a Buzzard.

The other three reports are of paracolon septicaemia in a Crested Serpent Eagle, a staphylococcal septicaemia in a Martial Hawk Eagle and toxæmia from abscesses of the foot in a Peregrine Falcon.

Violence

Two reports included, a Vulture and an Iceland Falcon (*Falco rusticolus islandus*).

Inconclusive, etc.

Reports on three Buzzards, two Kestrels, a Merlin (*Falco columbarius*) and a Marsh Harrier (*Circus oeruginosus*).

Period 1950-51

Fourteen deaths occurred during this period.

Two Buzzards, A50/2 and A50/5, both old stock, died within a few days of each other. The first had lived for nine months lacking the maxillary half of its beak. On examination some gelatinous material was found around the femoro-tibial joints and the cloaca was distended with liquid urates and a large calculus about one centimetre in diameter. The kidneys were not examined histologically but appeared abnormal to the naked eye. The second was reported as showing a 'degree of nephritis' not of diagnostic significance.

Three cases of tuberculosis were seen on post-mortem examination of a Griffon Vulture, A50/40, a Buzzard A51/52 and an Abyssinian Lanner (*Falco biarmicus abyssinicus*) A51/79, all old stock. In the Vulture caseous nodules were seen on the surface of the liver and caseous material was found lining portions of the thoracic and abdominal airsacs. Stained smears showed acid-fast organisms, but no examination for fungi was carried out. The Buzzard showed an injury to the wing, and caseous material was present on the airsac walls and in multiple nodules in the liver, lungs and kidneys. Stained smears showed acid-fast bacteria. The Lanner came from the same cage as the Buzzard, dying nearly a year later. It was emaciated and showed caseous foci throughout the liver, in the spleen where they were raised above the level of the capsule, and in the intestine as a few small white raised nodules. Acid-fast organisms were again seen in stained smears.

Eight of the remaining birds, A50/144, A51/38, 89, 91, 92, 112, 113, 117, were Kestrels. Three of these showed injuries, but in the other two examined no significant abnormality

could be found on bacteriological or histological examination. These birds are very aggressive, however, and it is almost certain that fighting was responsible for all eight deaths.

The ninth, another Buzzard, A52/169, showed severe splenic necrosis of bacterial origin.

ORDER PELECANIFORMES

This order includes the Pelicans, Gannet (Solon Goose) Cormorant and some other birds. The three mentioned are fish eaters and the only ones kept at Edinburgh. They are kept clipped or pinioned in a small grass paddock with a pond, in a large group.

The Cardiovascular System

One report, a Pelican with a 'flabby and dilated' heart. The bird was probably senile.

The Alimentary System

Reports concerning a Gannet (*Morus bassanus*) with intestinal obstruction and a Cormorant (*Phalacrocorax carbo*) are included here.

The Urinary System

Reports of two Pelicans, one with 'slight tubular nephritis' and one with nephritis and enteritis.

Dietary Disease

One doubtful report on a Gannet is included here.

Tuberculosis

The infection is described as being of spleen and liver in a Pelican and of intestine and liver in a Gannet which also showed an impaction of the proventriculus.

Special Diseases

One report of pneumomycosis and one merely 'mycosis' in two Gannets.

One of mixed leukaemia in another Gannet.

Violence

These three reports include a Cormorant killed fighting and two Pelicans with skin necrosis of unstated origin.

Inconclusive, etc.

One report on a Gannet included here.

Period 1950-51

The deaths during this period were five Gannets, A50/16, 36, 138, 143 and 135, and a Crested Pelican (*Pelecanus crispus*) A51/69.

The first of these was drowned by becoming trapped under the ice. The second showed epi- and endo-cardial petechiae, congestion of viscera and other signs of septicaemic infection. A *pasteurella* sp. organism was isolated from the tissues which, however, was found non-pathogenic to pigeons. The other three Gannets showed injuries attributed to the sea-lions with which they shared a pool. All were old stock.

The Crested Pelican died three days after it arrived in an undernourished condition. The cadaver was thin and there were healed fractures in two ribs. The pericardial sac contained clear fluid and the heart fat was soft and gelatinous. There was a heavy burden of lice, some of which had entered the oesophagus. Death was considered due to malnutrition.

ORDER PALAMEDEIFORMES

This order includes only the Screamers, which feed on certain water plants.

There are only three reports of post-mortem examination of these birds and all are inconclusive. Two mention infestation with lice. None have been in the park during the second period studied. It seems probable, the natural diet of these birds being so specialised, that the cause of death was connected with dietary factors.

ORDER PHOENICOPTERIFORMES and ORDER ANSERIFORMES

The former contains the Flamingoes, the latter the Ducks, Geese and Swans. They are dealt with together because of the small number of reports concerning Flamingoes and their close relationship to the Ducks and Geese. All these birds are clipped or pinioned and kept in small naturalistic paddocks with access to water. Their natural diet is similar, being derived from pond silt filtered through the beak and consisting of small crustaceans, etc., but in captivity it is supplemented with soaked bread and grain for the Ducks and a dried shrimp compound mixed with water for the Flamingoes.

Period 1938-49The Cardiovascular System

Disease of this system did not appear as the principal finding in any report, but a 'dilation of the right heart' is referred to in an Upland Goose (*Chloephaga magellanica*) with pulmonary congestion and 'flabby heart' in a Bar-headed Goose (*Anser indicus*).

The Respiratory System

Two reports included, a Whistling Tree Duck (*Dendrocygna fulva*) with 'oedema of the lungs' and an Upland Goose with pulmonary congestion and 'dilation of the right heart.'

The Alimentary System

Seven reports refer principally to enteritis. It is described as 'haemorrhagic' in a Muscovy Duck (*Cairina moschata*) and a Swan (*Cygnus olor*), the latter also showing emaciation and inflammation of the respiratory tract, as 'mucoid' in two Chinese Geese (*Cygnopsis cygnoides*) with congestion of the kidneys, as 'non-specific' in an unnamed Gender and just as enteritis in a Duck.

Five reports concern the liver, referring to 'cirrhosis' in a Bahama Duck (*Anas bahamensis*) and a Gender, rupture of the liver in a Muscovy Duck and of a 'fatty' liver in a Flamingo and 'hepatic changes' in a Red Flamingo (*Phoenicopterus ruber*).

The Urinary System

All nine reports are of nephritis. It was associated with osteomalacia in a Muscovy Duck, rickets in an Egyptian Goose (*Alopochen oegyptiaca*), 'visceral gout' in a hybrid Duck a Grey Lag Goose (*Anser anser*) and a Swan. The latter bird also showed an accumulation of grass under the tongue.

The remaining four reports concerned two *Cereopsis* Geese (*Cereopsis hollandiae*), a Poehard and a Swan.

The Reproductive System

Of these five reports, all Geese, three refer to 'egg-peritonitis,' one to impaction of the cloaca with an egg and one to prolapse of oviduct, cloaca and a portion of small intestine.

Dietary Disease

The only two references to deficiency affecting the bones were in reports included above under Urinary System.

The three included under this heading are two Swans and a Mandarin Duck (*Aix galericulata*) reported as emaciated of 'cachectic'.

Parasitic Disease

Worms of the genus *Amidostomum* are reported in a Hutchin's Goose (*Branta hutchinsii*) associated with impaction of the gizzard, in an emaciated Grey Lag Goose and in a Canadian Goose (*Branta canadensis*) and an Upland Goose. In addition, in a report on a Snow Goose (*Chen hyperboreus*) dying of a reproductive abnormality 'gizzard worm' is referred to.

Cestodes are reported in two emaciated Ducks and in a Pochard (*Nyroca ferina*) and a Hybrid Duck.

Roundworms associated with enteritis are reported in an Egyptian Goose.

Tuberculosis

The eight reports describe the infection as follows:-

'Generalised tuberculosis' in three Carolina (*Aix sponsa*) and one other duck.

'Pulmonary tuberculosis' in a Carolina Duck and a Shelduck (*Tadorna tadorna*).

'Advanced tuberculosis' in a Mandarin Duck.

'Tuberculosis' in an unnamed Duck.

Special Diseases

Two reports refer to 'pneumomycosis' in a Flamingo, and a Pochard.

Two reports are of 'fowl cholera' in Upland Geese ~~xxxxxx Pochard~~.

Three reports refer to suspected septicaemic conditions with Paracolon organisms in a Wigeon with '*B. faecalis*' in an emaciated Muscovy Duck, and with *B. coli* in an emaciated Swan showing enteritis.

The three other reports included here are of myeloid leukaemia in a Muscovy Duck, lymphatic leukaemia in a Call Duck and suspected fowl paralysis in an Upland Goose.

Violence

Four reports including one of a Muscovy Duck with 'abdominal' hernia.

Inconclusive, etc.

The 13 reports included here concern one Flamingo, three Swans, three Geese and six Ducks.

Period 1950-51

The six Chilean Roseate Flamingoes (*Phoenicopterus chilensis*) are here considered together.

A50/49. Old stock. This bird was in thin condition and showed abscess formation in the subcutaneous tissues of the right side of the head above the eye. The necrotising process involved a flat layer of tissue which is applied to the surface of the skull adjacent to the orbit and appears to be glandular in nature. In addition a loop of the intestine was impacted with pond silt for a distance of about nine inches.

A50/60. Old stock. This bird had been under treatment for a similar abscess condition of the head and after incising and expressing the purulent material protective dressings appeared to be producing an improvement. The bird, however, lost weight, became weak and died and post-mortem examination showed the abscess extending down the side of the face to the mandibular region. The only other abnormality was a necrotic caseating condition of the kidney.

A51/26. Old stock. This bird showed small chronic head lesions of a similar nature to the above but much smaller in extent. There were deposits of uratic material in the leg joints, and on the pericardium and other viscera, and the kidneys were full of urates when cut. They were not examined histologically.

A51/41. Old stock. The kidneys were pale, firm and 'gritty' on cutting, and on examination histologically, showed an increase in capsular and interstitial fibrous tissue. A number of calcified bodies resembling sectioned parasites were also visible.

A51/144. New arrival. This bird was in fat condition. There

was an old thrombus occluding the first branch of the aorta for a distance of about an inch. Also multiple 'pin-head' foci were seen in the liver and kidneys. Group C. haemolytic streptococci were cultured from the aorta and viscera, and also *Aspergillus fumigatus* from the aorta.

A51/138. New arrival. The principal findings were a impaction of the intestine with pond silt, periportal lymphocyte infiltration in the liver and casts in the renal secretory tubules. Coliform organisms were regained from the bone marrow.

Thirty-two Anserine birds were examined during this period.

The Alimentary System

A number of abnormalities were seen in the liver and intestines, but these mostly concerned young birds and are dealt with under dietary diseases.

The Urinary System

Evidence of renal disease was seen in three Ducks, A50/187, A51/13 and A51/35, all old stock, but only in the third of these was a histological examination made of the kidneys which showed hyaline changes in the glomeruli.

The Reproductive System

A50/167, a domestic Duck died a few days after arrival, showing a distension of the body cavity with egg material, i.e. 'egg peritonitis.'

A50/19, a Chinese Goose, old stock, was reported as dying from rupture of the mesenteric vessels due to prolapse of the bowel through a ruptured cloaca. This was initiated by a prolapse of the oviduct containing a soft-shelled egg.

Other Tissues

A chronic suppurative granuloma of the brachial muscle was the principal finding reported in an old Eider Duck A50/10 (*Somateria mollissima*), with cirrhosis of the liver and congestion of the alimentary canal. This had apparently arisen from a caseous ulceration of the caecum. Streptococci and paracolon organisms were recovered from the tissues.

Dietary Disease

Four young Cygnets, A51/88, A51/89, A51/96 and A51/107, died shortly after arrival. Only three were received for examination. Two showed bright yellow livers and one of these gave *Proteus* organisms on culture. The third showed a fibrous impaction of the gizzard. Bacteriological examination was negative in each case.

(*Anas platyrhynchos*)

Three one-month old Mallard Ducklings, A50/54, 55 and 59, hatched in the park, died showing impaction of the terminal portion of the large intestine with dry food material. Bacteriological examination showed only paracolon organisms.

A Spur-winged Goose (*Plectropterus gambensis*) A50/171, died the day after arrival. It was in very thin condition, had been overcrowded during the journey and death was ascribed to malnutrition, bacteriological examination being negative.

A young Swan, A51/7, died two months after arrival, in an emaciated condition.

Special Disease

An old Eider Duck, A51/141, showed a diphtheritic membrane lining the oesophagus. A profuse growth of the fungus of the genus *Monilia* was cultured from this and fungal mycelium was seen ramifying in the mucosa in sections stained by Claudius's modification of Gram's method.

Violence

Two Cygnets, A51/103 and 104, and a Mallard, A51/31, were killed by rats, one Ruddy Sheld Duck (*Caesarca ferruginea*) A51/10, by a Fox, and a Muscovy Duck A50/134, by an escaped Raccoon.

Two Swans, A50/147 and A51/23, were received with fractured wings. The first was destroyed with an intra-peritoneal injection of "Nembutal." (Abbot). / In the second an amputation was carried out, but the bird was too weak and died soon after.

A third Swan, A51/24, outgrew its clipped wing feathers and killed itself by flying into the tramway wires.

A Swan, A50/31, a Ruddy Sheldrake, A50/26 and a Muscovy Duck, A50/25, were killed by the Marabou Storks in the same enclosure.

A Chinese Goose, A50/24, died fighting.

Inconclusive, etc.

No diagnosis could be made in A51/19, A51/8 and A51/17. No examination was carried out on A50/126.

ORDER ARDEIFORMES

This order comprises the Herons, Egrets, Boatbills, Bittern, Shoebill, Storks, Ibises and Spoonbill. The smaller species are kept in outdoor aviaries, the larger are pinioned and kept in small enclosures. Most have access to pools and all are fed solely on fish.

Period 1938-49

The Respiratory System

The three reports included here are of pneumonia in a Common Heron (*Ardea cinerea*), 'haemorrhagic pneumonia' in an Egret and pulmonary congestion in another Egret.

The Alimentary System

Five reports are included here.

Impaction of the gizzard in a Painted Stork, also showing nephritis, and a 'fibrous' impaction in an Adjutant Stork (*Leptoptilos dubius*) with injuries.

Haemorrhagic enteritis is reported in a Night Heron (*Nycticorax nycticorax*) and intussusception in an Egret.

Rupture of the liver which showed degenerative changes in an Adjutant Stork.

The Urinary System

The six reports are all of nephritis. It is associated with hepatitis in a Night Heron and with 'visceral gout' in a Stork. The other four are in a Marabou Stork (*Leptoptilos crumeniferus*), a Painted Stork, a Night Heron and a Spoonbill (*Platalea leucorodia*).

Dietary Disease

The only report included here is that of a Marabou showing evidence of cachexia.

Violence

Three reports, two Painted Storks and a Marabou with a 'joint abscess' are included here.

Inconclusive, etc.

Three reports, on a Common Heron, a Bittern (*Botaurus stellaris*) and a Buff-backed Egret.

Period 1950-51

Five Black Headed Ibis (*Threskiornis melanocephala*), all old stock, died within five weeks of each other. A51/105 and A51/114 were reported as showing no significant lesions. Bacteriological examination of A51/97, 119 and 120 was also negative. Histological examination of the tissues of these three birds showed some degenerative changes in hepatic cells and in one case perivascular infiltration with lymphocytes and a few heterophils. Some indefinite changes in the epithelium of the renal secretory epithelium were seen in this one case, a few of the cells containing spherical a-nuclear bodies resembling fluke eggs. Dietary factors were considered a possible cause of death.

A Buff-backed Heron A51/72, old stock, was emaciated and its ventral feathers were matted together with excrement. A solid ball of uratic material occupied the cloaca, the ureters were dilated with gelatinous material and the kidneys showed degenerative changes in tubular cells and areas of lymphocytic infiltration.

A Snowy Egret (*Leucophoyx candidissima*) A51/80, old stock, was in an emaciated condition. The principal finding was a widespread lymphocytic infiltration of the kidney substance, the epithelium of the secretory tubules showing cloudy swelling and other degenerative change.

A Marabou Stork A51/66 showed injuries inflicted by its companions. Histological examination showed perivascular infiltration of the liver with lymphocytes and some heterophils, and a measure of degeneration of renal tubular and glomerular cells.

A Black-Headed Ibis Chick A50/173 died five days after hatching showing distension of the 'stomach' with fibrinous and indigestible material. The bones were soft and pliable.

In A50/11 a Snowy Egret, old stock, the stomach appeared distended with meat; there was some catarrhal congestion of the alimentary tract and a patchy congestion of the lungs. In A50/14 a Night Heron, old stock, the principal finding was partial blockage of the intestine with ingesta. a Buff-backed Heron, In A50/8, apart from a 'blanching' of the feet and small joint haemorrhages there was little abnormality. No significant lesions were seen in a Snowy Egret, A50/9. It is considered that the severe weather was partially responsible for these deaths.

In A50/61, a young Night Heron, hatched earlier in the year, there was some catarrhal congestion of the alimentary mucosa and a small area of haemorrhage at the base of the beak.

In A51/162, a White Bellied Stork (*Sphenorynchus abdimii*) a number of heterophils were seen in the liver and around the degenerating tubular secretory epithelium of the kidneys.

ORDER BALEARICIFORMES

This order comprises the Limpkin, Cariam, Trumpeter and the Cranes. Only the latter are kept at Edinburgh in any number and they are pinioned and occupy grass paddocks with Geese and other birds. They are fed mostly on soaked grain.

Period 1938-49

The Cardiovascular System

One report on a Demoiselle Crane (*Anthropoides virga*) gives 'dilated heart' as the sole finding and the same finding is reported in another with parasitic enteritis.

The Urinary System

Nephritis is the principal finding in one report on a Demoiselle Crane and is mentioned in a Crowned Crane (*Balearica* ?) with 'avian malaria.'

The Reproductive System

One Demoiselle Crane included here with 'egg peritonitis.'

Other Tissues

One Demoiselle Crane and one Crowned Crane showing 'anaemia' are included here.

Dietary Disease

The only report is of 'poor condition' in a Demoiselle Crane.

Parasitic Disease

In reports of five Crowned Cranes blood parasites of the 'avian malaria' group are referred to as the principal finding.

Haemosporidia were also seen in the blood of the Crowned Crane included under the Violence heading.

Intestinal infestation with *Ascaris* sp. is reported

in another Crowned Crane and 'roundworms' in a Dembiselle Crane with enteritis.

Tuberculosis

The three reports describe it as 'generalised' in a Common Crane (*Megalornis grus*) and just as 'tuberculosis' in another Common Crane and a Demoiselle Crane.

Violence

A Crowned Crane died a few days after pinioning. Haemosporidia were seen in the blood.

Inconclusive, etc.

One report on a *Cariama* (*Cariama cristata*) included here.

Period 1950-51

Six Cranes died during this period:-

- A50/131. Eastern Sarus Crane (*Megalornis antigone*) died at three days of age due to injury by parents.
- A50/198. Crowned Crane, old stock. No report received.
- A51/12. Young Eastern Sarus Crane born in the zoological park some months previously. This bird had a compound fracture of the fibia. The leg was amputated and dressed and the bird died while 'hanging in slings', its struggles causing the sling to cut into the tissues causing a fatal haemorrhage.
- A51/14. Crowned Crane. Old stock. This bird was required as a specimen by the museum. Viscera and blood smears examined showed no abnormality.
- A51/50. Crowned Crane. Old stock. This bird was lame for some time before death. The intestines contained a number of nematodes and the principal abnormality was widespread degenerative change in the liver and kidney. In the latter both secretory tubular epithelium and

and glomeruli being affected, very little normal tissue remaining. Bacteriological examination was negative but intra-corpuseular parasites resembling Plasmodium sp. were reported in blood smears. Some gelatinous material was seen in the joint capsules.

A51/168. An old female Eastern Sarus Crane had, unusually shown no signs of mating during the season. When caught up and examined there was found to be a long standing cloacal prolapse. This was reduced but the bird died some days later showing focal bacterial necrosis of the liver and spleen.

ANNANDALE

POLTON

ORDER CHARADRIIFORMES

This includes the Curlews, Sandpipers, Redshanks, Ruffs, Woodcocks, Snipe, Plovers, Avocets and Oyster Catchers. These are mostly 'waders' and feed on small water fauna. All are indigenous and those kept are in a covered aviary with access to a pool, being fed on ground meat and other foods.

Only small numbers are kept and there are few reports of post-mortem examinations.

Period 1938-49

Green Plover (*Vanellus vanellus*) Emaciation only.

Curlew (*Numenius arquata*) - Hepatic necrosis and haemorrhage.

Period 1950-51

A51/152. A newly arrived Sandpiper (*Tringa hypoleucos*), died after a few days. It was very fat and the only abnormality found was a fatty infiltration of the liver and renal secretory epithelium.

A51/158. A newly arrived Green Plover. Histological examination showed a focal infiltration of liver and kidneys with lymphocytes.

ORDER LARIFORMES

This includes the Gulls, Skuas, Kittiwakes and Terns. These are fish-eating British sea birds and are rarely kept captive as numbers of the commoner species frequent the park as visitors.

Period 1938-49

Gull (Larus ?) - inconclusive.

Ring-billed Gull (Larus ?) - extreme wasting.

Pneumonia.

Ring-billed Gull - 'visceral gout.'

Period 1950-51

An Arctic Skua (*Catharacta skua*), A50/132, and a Common Gull (*Larus canus*) A50/127, both died a few days after arrival. They were not examined post-mortem, the former being sent to the Royal Scottish Museum.

A51/93, a Black-headed Gull (*Larus ridibundus*) newly arrived, was emaciated and the vent feathers were clogged with excrement. The kidneys appeared pink in colour and the ureters dilated, but on histological examination all that was seen was disarrangement of otherwise apparently normal secretory tubule cells.

A51/115. Black-headed Gull. Old stock. Examination reported to be inconclusive.

A51/99. Black-headed Gull. Old stock. The only abnormality found was a slight degree of degenerative change in the renal tubular epithelium.

ORDER ALCIFORMES

This includes the Razorbill, Auk, Guillemot and Puffins. Like the preceding order they are fish eating birds, and in the wild state they inhabit the British coasts. Those at Edinburgh are clipped and kept in a small paddock with a pool.

Period 1938-49

Ten reports are of deaths occurring during this period.

One report concerns a Puffin (*Fratercula arctica*) showing only pulmonary congestion, one a Razorbill (*Alca torda*) with enteritis, which had aspirated some food material, and one a Little Auk (*Alle alle*) the findings being inconclusive.

The other seven reports concern Guillemots (*Uria aalge*). In four, parasitic infestation was the principal finding, 'roundworms' being mentioned twice, 'trematodes' once and 'nematodes' once. One report refers to inanition, one to 'pneumomycosis' and one to severe oiling of the feathers and alimentary congestion.

Period 1950-51

A50/42. Guillemot. Died a few hours after arrival. Condition thin, bruising of underside of beak, lungs appeared to contain fluid and the kidneys appeared pallid with ureters distended with uratic material.

A50/66. Guillemot. Died after several weeks in captivity, showing laboured respirations on the day preceding death. A quantity of caseous material was present in the left abdominal airsac, and a number of 'pin-head' nodules were scattered throughout the corresponding lung. These lesions were considered due to a fungal infection.

A50/72. Guillemot. Old stock. The principal abnormalities were a white deposit on the viscera and an excess of

urates in the kidney which exuded when the organ was cut. Not examined histologically.

A51/15, 18 and 19. Three Guillemots all arrived and died within a few days of each other, which is evidence that they had suffered similarly from rough sea conditions and been washed up in the district. Two of the birds were badly 'oiled', one showing petechiation of gizzard and duodenum and two patches of mycotic growth resembling *Aspergillus* on the lung, and the second being thin and having somewhat 'uratic' kidneys. The third showed nothing excepting a similar appearance of the kidneys.

ANNANDALE

POLTON

ORDER SPHENISCIFORMES

As stated in the introduction, this order is dealt with separately, the importance of Penguins at Edinburgh Zoological Park being such that they merit more detailed discussion.

In order to permit comparison with other orders, however, and to enable total mortality figures for Aves to be computed, a column has been devoted to this order in Table D .

The difference between the figures given in this table and those in the special section is due to the inclusion in the latter section of deaths for which no post-mortem report is available; and to the exclusion of chicks.

ANNANDALE

POLTON

ORDER PODICIPIDIFORMES

The order includes only the Grebes, which are fish-eating British water birds.

The one report refers only to a 'feather ball' in the gizzard of a Grebe (*Podiceps* ?).

It is interesting to note W. P. Pycroft's remark about the Grebes that "they alone among the birds use their own feathers in place of gizzard stones." ("Animals of All Countries" p. 918. Hutchinson 1927).

None have been kept during period 1950-51.

ANNANDALE

POLTON

ORDER RALLIFORMES

This includes the Rails, Woodhens, Crakes, Moorhens and Coots. These are water birds feeding on water fauna. Most of these kept are indigenous, although the Purple Gallinule comes from the Mediterranean, and they are kept in small numbers in paddocks or aviaries provided with pools. They are fed on the same diet as the ducks in captivity.

Period 1938-49

Water Rail (*Rallus aquaticus*) - inconclusive.

Purple Coot (*Porphyria coeruleus*) - 'nephritis'.

Period 1950-51

In A50/13, an old Coot (*Fulica atra*) the principal finding post mortem was a catarrhal thickening and congestion of the duodenum. Bacteriological examination of the heart blood isolated paracolon organisms, probably contaminants.

A51/68, a Purple Gallinule, died the day after arrival in an emaciated condition. Little abnormality was seen on post-mortem examination excepting that the contents of the intestine appeared unusually dry. Bacteriological examination was negative and death presumed due to inadequate nutrition during travel.

ORDER COLUMBIFORMES

This order includes the pigeons and doves. They are housed in outdoor aviaries and fed on grain, principally maize.

Period 1938-49The Cardiovascular System

One report refers to myocarditis apparently of bacterial origin in a Pigeon and another to 'dilation of the right heart' as sole finding in an Eastern Dove (*Streptopelia orientalis*).

The Respiratory System

Five reports refer to pulmonary congestion:- Two Bronze-naped Doves (*Leptotila chalcabuhenia*), two Turtle Doves (*Streptopelia turtur*) and a White-breasted Dove (*Leptotila jamaicensis*).

Pneumonia in a White Dove from which an organism of the *Pseudomonas* group was isolated in the sixth report included.

The Alimentary System

Eight reports refer to enteritis as the principal finding. In a Green Pigeon and a White-breasted Dove *B. coli* was the only organism isolated. In another Green Pigeon it is described as 'frothy mucoid' and a dietary cause is suggested. In five more Green Pigeons it is not described.

The other two reports included here of "severe indigestion" in an African Dove and disseminated hepatic necrosis in a Turtle Dove.

The Urinary System

One report - of nephritis in a Green Pigeon.

The Reproductive System

Two reports - of 'egg peritonitis' in a Vinaceous Dove (*Streptopelia vinacea*) and an Eastern Dove.

Dietary Disease

The one report included here refers to 'osteomalacia' in a Wood Pigeon (*Columba palumbus*).

Parasitic Disease

'Threadworm' infestation in a White Breasted Dove and 'tapeworm' infestations in a West African Dove and a White Breasted Dove are reported.

Tuberculosis

One report of the disease, undescribed, in a Tibetan Turtle Dove.

Special Diseases

Three reports of suspected septicaemia, in a Green Pigeon, a White Dove and with *Bacterium coli* in a White Breasted Dove.

Violence

One Jacobin Pigeon is the only report included.

Inconclusive, etc.

Nine reports included here.

Period 1950-51

The deaths include nine Doves and five Pigeons, references A50/20, 123, 157, 172, 183, 184, 196, 199 and A51/6, 7, 9, 11, 51 and 73.

Four Doves and one Pigeon were not received for examination. All the remaining nine birds showed evidence of injury. One was accidentally killed by a keeper, three were apparently killed by rats and three showed fighting injuries. The other two birds showed hepatic abnormalities, in one case fatty change and in the other severe congestion, but the significance of these findings is doubtful as both birds showed injuries.

ORDER GALLIFORMES

This includes the 'game-birds', the Domestic Fowl, Pheasant, Turkey, Pea-fowl and others. These are mostly graminivorous, though they do catch some worms and insects. The Pheasants are kept in small groups, usually pairs, in separate divisions of a covered, sand-floored aviary, and are fed principally on soaked grain. The Pea-fowl are kept similarly. The domestic fowls are kept in groups and fed ordinary poultry mash.

Period 1938-49

The Circulatory System

One report of endocarditis in a Turkey (*Meleagris gallopavo*) with enteritis and one of hydrops pericard in a Peacock (*pavo cristatus*).

The Respiratory System

Three reports of pulmonary congestion, in a Monal Pheasant (*Lophophorus impejanus*) and a Guinea Fowl.

One report of 'pneumonia' in an Amherst Pheasant (*Chrysolophus amherstii*) and one of 'oedema of the lungs' in a Golden Pheasant (*Chrysolophus pictus*).

The sixth report, on a Peacock, refers to 'fluid in the lungs.'

The Alimentary System

The Stomach and Intestines:

Three reports of 'enteritis' in a Tragopan Pheasant, a Seabrights Bantam and a Blue Turkey.

One report of 'bilateral typhlitis' in a Jungle Fowl (*Gallus gallus*).

One report of impaction of the gizzard in a Hen and one of caseous impaction of the caecum in a Peafowl.

The Liver:

Eight reports are included. A Bantam is reported as showing 'cirrhosis of the liver' with accompanying enlargement of the heart. Six concern Pheasants showing, in two cases rupture of the liver, one hepatic abscess, one hepatic necrosis, one 'hepatitis and peritonitis' and one hepatic fatty degeneration and cavernous haemangioma.

The eighth report concerns a Turkey with streptococcal abscesses of the liver and spleen.

The Urinary System

Nephritis is referred to three times, in reports on a Turkey and two Cheer Pheasants (*Catrius wallichii*), in one of the latter being associated with 'visceral gout.'

'Visceral gout' alone is mentioned in reports on a Guinea Fowl and a Bantam.

The Reproductive System

The three reports are of 'egg-peritonitis' in a Leghorn and a Turkey, and of 'egg binding' in a Painted Quail.

Other Tissues

One report of 'chronic splenitis' in a Turkey.

Dietary Disease

One report of 'rickets' in a Common Pheasant (*Phasianus colchicus*).

Parasitic Disease

In 11 reports parasites form the sole or principal finding.

'Heterakis' infestation in two Tragopan Pheasants, a Guinea Fowl and a Peafowl.

'Roundworm' infestation in two Pheasants.

'Trichostrongyle' infestation in a Red Jungle Fowl.

'Tapeworm' infestation in two Bantams.

'Coccidiosis' in two Red Jungle Fowl.

In addition to these, parasites are mentioned in six reports classified elsewhere. 'Roundworms' in a Guinea Fowl, and with a concurrent 'Syngamus' infestation in a Golden Pheasant. 'Tapeworm' in a Silver Pheasant, 'Raillietina' in a Golden Pheasant and infestation of the airsacs with mites in another Golden Pheasant. A heavy infestation with external mites is reported in a Hybrid Fowl.

Neoplasia

Not including the 'leukosis complex' which is classified under 'Special Disease', the reports are as follows:-

Neoplasia in a Bantam

'Neoplasia of the kidney region' in a Bantam

Neoplasia of the ovary with secondary metastases in a Rhode Island Red.

Tumour of the ovary in a Fowl.

Hepatic carcinoma in a Hen.

Neoplasia in a Jungle Fowl.

Tuberculosis

There are 63 reports of Tuberculosis in gallinaceous birds, the infection being described as

Generalised in 25 Pheasants of various species

8 Fowls of various breeds

2 Turkeys

2 Jungle Fowl

2 Peafowl

'Abdominal' in 3 Golden Pheasants

1 Pekin Bantam

'Of liver and spleen' in 1 Turkey

'Advanced' in 1 Monal Pheasant

Not described in 12 Pheasants (one of which had an impacted caecum)

4 Turkeys (one of which was 'egg bound')

1 Guinea Fowl

1 Hen

Special Diseases

Mycosis: Five reports, three described as pneumomycosis in two Pheasants and a Guinea Fowl, and two cases not described in Monal Pheasants.

Other Diseases

One report of suspected 'fowl cholera' in a Peacock.

Two reports of apparent septicaemic conditions from which only Proteus organisms were isolated in Pekin Bantams.

One septicaemia originating from a joint abscess in a Peacock. One report of "salmonellosis" in a Cheer Pheasant.

One isolation of Salmonella pullorum from the tissues of a Silver Pheasant (Gennoeus ?).

Violence

Four reports, a Fowl, a Guinea Fowl, a Pheasant and a Peacock.

Inconclusive, etc.

Reports of three Pheasants, four Fowls, three Painted Quail and three Jungle Fowl are included here.

Period 1950-51

A50/33 Pekin Bantam. Died after transfer to new quarters.

A very old bird with hyperkeratinised leg scales and long spurs.

The lungs were uniformly congested and the oesophagus

contained some mucus. The body cavity contained some serous

fluid. Bacteriological examination was negative and death

considered due to congestion of the lungs subsequent upon the

shock of transfer.

A51/34. Seabright Bantam. Old stock. The principal findings were foci of bacteria and inflammatory cells in the congested consolidated lung tissue and some periportal lymphocytic infiltration in the liver. Bacteriological examination was not made and death considered due to pneumonia.

A50/3. Silver Pheasant, aged 12 years. This bird was emaciated and showed hepatic fibrosis.

A51/95. Golden Pheasant. This old bird showed hepatic fibrosis with areas of cell atrophy and of partial regeneration.

A51/161. Spangled Bantam. The principal finding was impaction of the crop with maize grains.

A51/194. Guinea Fowl. Old stock. The intestines showed a catarrhal congestion and a fairly heavy nematode and cestode infestation.

A50/65. Brush Turkey (*Alectura lathami*), aged about 13 years. This bird passed a fully formed egg a few minutes before death. There appeared to be some hepatic fibrosis and the endocardium showed fibrotic areas at the auriculo-ventricular margin, which were confirmed by histological report.

A50/41. Monaxl Pheasant. Old stock. This bird had been injured by its mate ten days before death. The principal finding was an inflammatory condition of the oviduct which contained pieces of broken egg shell.

A51/59. Bantam Hen. Old stock. A black horny growth was attached to the abdominal skin. The bird was over-fat. Histological examination showed much lymphocytic infiltration of lungs, liver and kidney tissue and the general appearance was of disease of the 'avian leukosis' type.

A50/62. Amherst Pheasant, and A51/45 Silver Pheasant were destroyed because of dry gangrene of the foot subsequent in the first case to abscesses of the 'bumblefoot' type and in the second case to injury. This latter bird showed what appeared to be thrombosis of the posterior vena cava.

The three Pheasants A50/124, 67 and 18, were killed fighting. A Guinea Fowl A50/12 showed numerous injuries presumed due to rats, and a nematode infestation of the intestines. A Black Bantam A51/81 showed multiple external injuries also. All these were old stock.

A Peahen A51/29, an old emaciated bird, showed no significant lesions on macroscopic and histological examination.

Post-mortem examination was also inconclusive in A51/37, a Common Pheasant, and A50/35, a Silver Pheasant, which gave a negative bacteriological examination as well.

ORDERS CASUARIIFORMES, RHEIFORMES and STRUTHIONIFORMES

These orders are dealt with together in view of their many similarities and the small number of reports on each order. The first includes the Cassowaries and Emus, the next the Rheas and the last the Ostriches. All are flightless birds and they are kept in grass paddocks throughout the year, their diet being supplemented with maize.

Period 1938-49

The Cardiovascular System

In three reports heart lesions appear to be the principal finding.

'Vegetations' (presumably endocardial) in a Rhea (*Rhea rothschildi*) with a cirrhotic liver and filarial infestation.

'Heart lesions' in an Emu (*Dromiceius n. hollandiae*) with a cirrhotic liver and showing general venous congestion.

'Valvular incompetence' in a Cassowary (*Casuarus casuarus*).

In addition, mention is also made of a dilatation of the heart in another Emu and of atheroma in a Rhea dying from other causes.

The Respiratory System

The only report included is of pulmonary congestion in an Ostrich (*Struthio camelus*), this being the sole finding.

The Alimentary System

Four reports refer to impactions: of the oesophagus in an Emu, of the crop in a Darwin's Rhea (*Rhea pennata*), of the proventriculus in one Ostrich and of the gizzard in another. Impaction and intussusception are referred to in a Rhea with tuberculosis and it is included under that heading.

Two other reports refer to the 'stomach': one of 'severe gastritis' in a Cassowary and one of lacerated provent-

riculus caused by a stone in an Ostrich.

The remaining three reports are of 'enteritis', volvulus of the small intestine and volvulus of the large intestine in three Ostriches respectively.

Dietary Disease

The one report is of cachexia in an Ostrich.

Parasitic Disease

No report mentions parasitism as the sole or principal finding, but 'Filariae', 'Roundworms' and 'Helminths' are referred to in three reports on Rheas respectively.

Tuberculosis

The four reports are all of Rheas. The infection is described as being of liver and spleen in one report. In two others it was associated in one with intestinal impaction and intussusception, and in another with enteritis and atheroma.

Violence

One report, an Ostrich, with subcutaneous oedema and haemorrhage in the cervical region, the cause being presumed to be violence.

Period 1950-51

Four Ostriches were the only members of this group to die during the two years.

A50/4. Female, aged about three years. 6th January, 1950,

found 'down', eyes closed, head laid back, apparently in pain.

Treated with warm milk, brandy and two doses of 5 fl. oz.

liquid paraffin. A cloacal examination revealed gritty, grey faeces.

7th January: Cloacal temperature 95.5°. Treatment continued.

Liquid excrement voided but no solid. Died during night.

Post-mortem examination showed a quantity of long grass in

the proventriculus and gizzard and severe intestinal congestion.

A50/39. Male, young adult. 14th April, 1950: Found 'down', apparently in pain. Cloaca contained only mucus. 1.5 grammes 'Thelazole' administered in liquid paraffin twice.

18th April: Struggling, straining and apparently attempting to vomit. 2 oz. Magnesium Sulphate given. Died at 7 p.m. Temperature 95.5°.

Principal post-mortem findings were:- Epi- and endo-cardial haemorrhages. Much pericardial fluid. Proventriculus contained 5 lbs. weight of gravel and a ball of long grass which completely filled the lumen.

The intestines were intensely congested and the mesentery showed numerous haemorrhages. *Bacterium coli* was the only organism isolated from the tissues.

A51/21. Male. Young adult.

16/1/51. Staggering slightly.

17/1/51. Prostrate. 5 grammes Sulphamezathine by mouth.

18/1/51. Neck coiled. Appeared to be in pain. Some nasal discharge. Thermometer not registering when placed in cloaca.

Principal post-mortem findings were:-

General condition - very fat, a layer two inches thick lining the abdomen.

Pericardium distended with fluid. Large epi- and endo-cardial haemorrhages.

Firm, yellowish 'greasy' liver.

Proventriculus impacted with long grass and stones.

Duodenum intensely congested.

Bacteriological examination revealed a varied flora.

A51/28. Young adult male. Died 27/2/51.

This bird showed an almost identical picture symptomatically, and on autopsy, to A51/21. The fatty condition of the liver was, however, so advanced that no cells not distended by fatty globules could be seen on microscopic examination. The kidney was imilarly affected.

22/2/51: Unsteady on legs. A noted authority on poultry was consulted, who advised minerals and yeast which were administered.

24/2/51.: No change.

25/2/51 : Prostrate. No faeces passed.

26/2/51 : Lying on one side. Liquid faeces, no solid.

Laboured respirations.

Principal post-mortem findings were:- Endo- and epi-cardial haemorrhages, 'greasy' liver, much long grass and stones in proventriculus and gizzard. Haemorrhages throughout the intestine.

CLINICAL NOTES - THE BIRDS

Very little clinical work has been carried out on birds. Symptoms are frequently not shown until the condition is too far advanced for treatment, and among groups of birds the earliest symptoms are noticed first by the other birds which thereupon attack and frequently kill the sick one. In addition many of the birds are very delicate creatures and the harm done in isolating them for examination is often worse than the original disease. As L. J. Goss () says, "the therapeutic hazard must not exceed the disease risk."

Mention is made in the Penguin section of treatments employed against mycosis with little or no success. Empirical dosage with sulphamezathine has been given on several occasions in other sailing birds. Fractured wing and leg bones have occasionally been splinted or encased in plaster and on other occasions amputated.

The destructions of severely injured birds have been carried out by the use of 'Nembutal' (Abbot) employed either intra-peritoneally or intravenously. The latter route has been used in a King Penguin among others, the injection being made into the brachial vein at the trailing edge of the flipper about two inches from its junction with the body.

The operation most frequently carried out on birds is that of pinioning, i.e., removal of a portion of one wing to prevent flight. At the writer's first attempt the method previously in use was employed, that is, the disarticulation of the metacarpal bones from the radius and ulnar, the severance of the neighbouring soft tissues and thus removal of one third of the wing. The wound was left unsutured, perichloride of iron being used as a haemastatic and healing though slow was

usually uneventful and satisfactory. The operation is, however, crude, leaving the bird stained with blood, and after healing the wing has a 'stumpy' and unnatural appearance.

Since that time amputation has been limited to the two phalanges of the second or terminal digit. 'Novocaine' one per cent solution (Bayer) is injected subcutaneously above the joint on dorsal and ventral surfaces in the region of the nerve and also is infiltrated around the site of the incision. 1 - 2 cc's. in all is used according to the size of the bird. The joint is disarticulated and the rudimentary third digit is removed as well. When cutting back through the soft tissues, the line of the primary flight feathers is followed as, if these are cut, troublesome haemorrhage may occur. Perichloride of iron is used if necessary and healing again is uncomplicated. Recently a skin flap has been left and sutured over the wound which improves its appearance and promotes healing. The disadvantage of this method is that short flights can still be made.

Methods described in the literature are diverse. Schroeder and Koch (1940) carry out bilateral tenotomy by burning through the skin and through the tendon of the Extensor Metacarpi Radius longi with an electrically heated needle just above the carpal joint where the tendon runs subcutaneously across the lower end of the radius. Young (1948) describes a pinioning operation involving amputation after which the end of the exposed bone is sawn off and a flap of skin sutured across with catgut. The joint at which this is done is not clearly named, but is presumably the radio-carpal.

The practice of removing the terminal digit only is
quoted
described by Crendall (by) and is employed at Whipsnade (pers.
Schroeder

comm.) and at other zoological gardens as evidenced by some of the birds received at Edinburgh.

Campbell (1934) describes the use of ether as a general anaesthetic in birds which he pinions at the 'wrist' joint. He has apparently found the use of this anaesthetic safe in over 100 cases. He also advises bandaging the wound.

A method of tenotomy in young birds a few days old has also been described, but it has been suggested that this may cause the wing to droop in later life.

ANNANDALE

POLTON

THE BIRDS - DISCUSSION

In view of the fact that only in a minority of avian orders has the number of birds examined been large enough to be significant, individual discussion of the orders has not been attempted. Also, as stated previously, morphological differences are much smaller between the avian than between the mammalian orders. In addition, nearly one-quarter of the total of the reports analysed were inconclusive, which makes all the figures less reliable. However, a number of differences between the orders with the largest number of autopsies are apparent from Table E and these are referred to below.

The Cardiovascular System

Only in 1.4 per cent of reports did lesion of this system appear as the principal finding on post-mortem examination and the majority of these were indefinite. It is possible that some minor lesions may have been overlooked by the writer and by previous investigators, but at least they cannot have been of common occurrence. While the figures for all orders are too small for comparison to be valid, the fact that three of the 19 'Ratitae' to die showed heart lesions is interesting and may be connected with the long life these birds live in captivity. The Psittaciformes also live to a great age, and in these birds the aorta gives the impression of being firmer than usual and showing slight intimal roughening more often than the figures suggest.

In Fox's detailed analysis (1925) 1.8 per cent of all birds examined showed vascular abnormalities. Though the figures given for heart disease overlaps somewhat with these, it seems probable that the total of cardiovascular disease was recorded

was somewhat higher than that at Edinburgh. The order Accipitriformes was the most commonly affected of these on which a large number of autopsies was carried out, but it is also stated that of 32 'Struthionies' examined, 11 showed heart disease. This order belongs to the Ratitae, and the same author (1932) reports a case of arteriosclerosis in an ostrich.

Hamerton's figure, which is not really comparable as it includes blood diseases, is as high as 4 per cent of all birds dying.

There are many cases of cardiovascular disease referred to in the reports of the London Society (1944, 1946, etc.) and Hamerton (1939) describes it as "the usual terminal event" in aged birds. Rewell (1948c), however, describes true atheroma as rare in birds and implies that arterial degenerations of any kind are slight and uncommon. Elsewhere in the same paper he comments upon the not infrequent occurrence of bacterial endocarditis.

Noting the conclusions resulting from a further study of arteriosclerosis at Philadelphia, Fox (1935) states that "The disease appears not characteristically to shorten the life of menagerie specimens; it may contribute to a fatal illness and has caused death by itself."

These remarks of both Rewell and Fox appear to conflict somewhat with Hamerton's statement, unless he was referring more to cardiac than to vascular disease.

The writer has not examined a comparable number of birds, but cardiovascular disease has certainly not appeared as a common finding even in old ones.

The Respiratory System

There appears to be a very real difference between the orders in relation to respiratory disease, the six orders upon which there are 75 or more reports showing the following figures:-

Psittaciformes	-	20.1	per cent	±	7.8
Passeriformes	-	17.3	" "	±	6.9
Galliformes	-	5.0	" "	±	5.1
Accipitriformes	-	4.0	" "	±	6.6
Sphenisciformes	-	3.4	" "	±	4.9
Anseriformes	-	2.0	" "	±	3.9

A statistically significant difference does therefore exist between the first two orders and the remainder, but the Sphenisciformes must be excluded from the discussion in view of the high level of respiratory mycosis. This is included under the 'Special Disease' heading and therefore not evident in these figures.

The majority of the reports refer merely to a congestion of the lungs and this has been taken as the principal finding only in the absence of other major findings. A pulmonary congestion alone, that is with no cellular reaction, is recognised as being sufficient to cause death in small birds and reference is made to it by Osman Hill (1951), who states that "In birds death appears to occur frequently during the initial stage of inflammatory congestion, i.e., before consolidation takes place. This is almost certainly correlated with the inability of birds to cough and expel the exudate - due to the peculiar morphological relationship of their lungs."

The frequency of this diagnosis in the two orders would seem to be due firstly to the size of the birds affected; all the passerine species are small and budgerigars form the

bulk of the psittacine cases; and secondly to the type of housing. The species exhibited of both orders are mostly tropical and as stated above are kept in a heated house but have access to outside cages. It would seem possible that, although the intervening trapdoor is only opened in the more temperate weather, danger of sudden change in temperature is greater under this form of management. The only other birds kept in this house are species of the order Coccothraupiformes and a large enough number have not been examined to permit any conclusion to be drawn. Mention may also be made of the apparently high number of Columbiformes, with the same reservation, but these are kept outdoors entirely.

Fox (1923) does not give exactly comparable figures but he states that "-- congestion is to be looked upon as serious particularly in passerine birds." Referring to pneumonia, he says that only in the Passeriformes is there an incidence comparable to that seen in the important mammalian orders. In his table the largest number of cases are shown in the Passerine birds and the next largest in the Psittacine.

Hamerton's figure of 13.8 per cent (Table E) is considerably higher than the writer's. This may be due to the tendency of housing many varieties of birds indoors continuously, to different atmospheric conditions, including greater pollution, or merely to a differing choice of primary factors in those analysing the reports.

The Alimentary System

Of the reports included under this heading about one-third concerned the liver and the remainder the alimentary canal proper. Very few inflammatory conditions of the oesophagus,

crop, proventriculus and gizzard were seen or reported: impactions and obstructions accounted for all but a few of the cases, no doubt because of the resistant nature of these organs in birds. Inflammatory conditions, however, formed the majority of the abnormalities seen or reported in the intestines. Only one report is made of intussusception and few of prolapse. The intestines appear to have shown abnormalities about twice as frequently as the gizzard and proventriculus.

The frequency of affection of the various orders is shown in Table F which places them in the following descending scale.

Accipitriformes	-	16.0	per cent
Psittaciformes	-	15.7	" "
Galliformes	-	10.6	" "
Passeriformes	-	10.5	" "
Anseriformes	-	9.7	" "
Sphenisciformes	-	7.8	" "

The difference between neighbouring orders is not statistically significant, but that between most frequently and least frequently is sufficiently wide to serve as an interesting indication.

The difference between the orders appears to concern the alimentary tract as a whole, that is, it is not due to any particular susceptibility of the liver, 'stomach' or intestine in any one order.

Fox (1923) does not give exactly comparable figures, but lists the percentage of cases of gastro-entero-colitis found in the various orders whether principal finding or not. Considering that hepatic disease is excluded, the percentages

appear to be remarkably high.

Strigiformes	-	41.5	per cent
Accipitriformes	-	40.0	" "
Galliformes	-	38.6	" "
Psittaciformes	-	36.6	" "
Anseriformes	-	29.6	" "
Passeriformes	-	23.6	" "
Columbiformes	-	17.8	" "

This list places the two principal orders of raptorial birds at the top and is somewhat similar to the arrangement of the orders in the list for Edinburgh. Table D shows the Strigiformes to be quite frequently affected and if there were a sufficient number of autopsies the inclusion of this order would probably increase the similarity between the lists. In addition, the Sphenisciformes, which is another raptorial order, would come higher upon the list for Edinburgh if cases where alimentary abnormality was a secondary finding were included.

That raptorial birds would show a higher incidence of alimentary abnormality is to be expected. A diet approaching the natural food is more readily provided for seed eaters than for carnivorous birds. Although the latter are given some freshly killed rodents, a part of their diet is made up with horse flesh, and in the case of the penguins, fish replaces the natural food of squids and crustacea.

Table D also shows a high incidence of alimentary abnormality in the small number of the Ratitae. Thirteen of the 23 examination showed alimentary abnormalities, many of which were impactions due probably to incorrect pasturage.

Hamerton's figure (Table E) for the percentage of total avian mortality due to alimentary affections is considerably

higher than the writer's, perhaps due to a different interpretation of findings. Diseases of the liver and the alimentary tract proper are summated for the purpose of comparison, but the frequency of the former appears to have been much less than at Edinburgh. Nothing of the nature of the virus hepatitis described at Philadelphia by Lucke and Ratcliffe has been seen, however. Rewell (1950) found advanced hepatic fatty change in many birds for "no apparent reason."

The Urinary System

The majority of the reports included under this heading for the period 1938-49 use the term 'nephritis' without mentioning histological examination, or the other criteria leading to the diagnosis. Histological examination of many kidneys has been carried out during 1950 and 1951, and some degree of abnormality has been found on many occasions. In fact, changes in the cytoplasm of the epithelial cells of the larger collecting tubules, and of the more superficial secretory tubules, have been seen in almost every section examined. This has been considered an artifact and of no significance unless very advanced, and has been particularly noticeable in sections of Penguin kidney. Cloudy swelling of the epithelial cells of all the secretory elements has also been seen very commonly, and in general, degenerative changes in the renal tubular epithelium have not been considered of primary significance unless involving the nucleus. Fatty change has been seen but rarely, lymphocytic infiltration infrequently and heterophilic infiltration only on one or two occasions. Hyaline change in the glomeruli has been noted several times.

Rewell (1948a) describes the interpretation of sections of the kidneys of birds and reptiles as "largely

speculative," and though Spector's monograph on the "Nature of the fowl nephritis" clarifies many points, the pathology of the bird's kidney remains less well understood than that of the mammals. One of the factors that makes interpretation difficult is that post-mortem change appears to take place more rapidly, possibly because the bird's kidney is not well encapsulated as is the mammal's, and so is more readily affected by putrefactive organisms from the intestine.

Although a fairly large number of kidneys have been examined histologically, they have been from a great variety of species and ages of birds, and it has not been possible to examine a series of sections from the same kidney or in any way to attempt a detailed investigation of this one organ. As stated the lesions most commonly seen have been degenerative changes of the tubular secretory epithelium. Quite frequently an increased amount of interstitial fibrous tissue has been present, occasionally with roundcell infiltration, and dilatation and distortion of the secretory tubules. Occasionally also, the tubules have contained casts, either hyaline and round in cross section, or composed of debris. These changes resemble some stages of fowl pyelonephritis described and illustrated in Spector's monograph, although the tubules choked with urate material and the sunflower bodies he describes have been seen rarely if at all. (See also discussion of Reptiles). Hamerton (1940, 1944) refers to this picture of tubules choked with urates in the kidneys of a number of birds in the London collection, and the absence of these findings is therefore somewhat surprising. The method of section preparation is the same as that used by Spector except that 5 per cent formalin has been employed instead of 10 per cent formol-saline.

It seems probable that the urate material must have dissolved out at some stage in the process.

Osman Hill (1952) discusses the occurrence of chronic interstitial nephritis with deposits subcutaneously on serous membranes and in subcutaneous tissues. He states that this condition causes the death of many birds especially those long in captivity. At Edinburgh some degree of kidney abnormality has been seen in all cases of visceral and arthritic 'gout' occurring during the period 1950-51, but in six of the 15 reports of 'gout' during the period 1938-49 no mention of kidney disease is made. The orders in which this condition has been seen or reported are Sphenisciformes, Anseriformes, Phoenicopteriformes, Psittaciformes, Galliformes, Ardeiformes, Alciiformes and Lariformes. Osman Hill (1952) gives a description and photographs of an advanced case of avian gout in a Conure associated with parathyroid abnormality. A photograph of a Parakeet is appended here, in which the distribution of deposits is very similar.

Hamerton (1941) describes 'uraemic fits' in a Penguin and (1943) renal calculi in a Flamingo.

Fox (1923) gives a general incidence of avian nephritis alone of 7.7 per cent, the orders being affected in the following descending frequency,

Accipitriformes

Strigiformes

Anseriformes

Psittaciformes

Columbiformes

stating that, like Carnivora, Accipitriformes "occupy a definite position in the analysis of acute and chronic lesions, their

kidneys showing the smallest percentage of acute and the highest percentage of chronic lesions. He also finds true renal calculi of rare occurrence in birds, and remarks on the frequency of tubular degenerations as compared to glomerular ones. Referring to avian gout he classes it as most frequent in Parrots, Gallinaceous birds, Anserine birds and Herons and occasionally in Accipitrine birds. The indication at Edinburgh, although the number of cases of gout is not very large, is similar except in the case of Herons and, as stated above, Accipitriformes.

The Reproductive System

Almost all the cases included under this heading have been either of so-called 'egg peritonitis' or of 'impaction' of the oviduct with a soft-shelled or otherwise abnormal egg.

Table 3 shows the frequency with which the orders have shown these findings, i.e.,

Psittaciformes	-	7.4	per cent
Anseriformes	-	6.8	" "
Galliformes	-	2.5	" "
Passeriformes	-	2.3	" "
Sphenisciformes	-	very small	
Accipitriformes	-	none.	

These figures are small for statistical estimation.

Fox gives comparable figures for several groups of birds, the percentage affected being much smaller, thus:-

Gallinaceous birds	-	2.3	per cent
Anseres	-	1.6	" "
Struthionies	-	1.5	" "
Passeres	-	0.6	" "

and he concludes that the incidence is not related to that of

infectious disease or to relative egg size.

It would appear from the writer's figures that the availability of calcium in the diet might be connected with the frequency as there are few reports of any abnormality among the raptorial birds. The difference between the Psittaciformes and the Passeriformes, which is definitely significant (7.4 per cent \pm .5 and 2.2 per cent \pm 2.6) statistically, is perhaps connected with some differing calcium content of the smaller and larger seeds.

Many cases of "egg-binding" and egg-peritonitis are reported at London. Hamerton's figure of 2.4 per cent is not greatly dissimilar from Edinburgh's of 3.2 per cent.

The Nervous System

Nothing can be said here except that it seems likely that a few cases must have been missed.

Dietary Factors

Bone disease throughout appears to have been very rare, possibly due to the birds' habit of consuming limestone grit for use in digestion, although a deficiency of calcium appears to occur for egg production.

The only orders showing fairly high figures for disease due to dietary insufficiency, deficiency or other dietary factor are the Anseriformes and the Sphenisciformes. In the former the majority of the deaths were in young chicks incorrectly housed, this order being that in which by far the most breeding occurs. In the Sphenisciformes most deaths were among newly arrived Penguins which had probably been incorrectly fed on the voyage. The general infrequency of cachetic and emaciated birds received at post-mortem, except those newly arrived, reflects the high level of feeding which is employed. It may be,

however, that many deficiencies of one or more factors go undetected, and considering the frequency of hepatic and renal degeneration this may well be so. Alternatively, the birds' complete dietary requirements may be more easily met than the mammals'.

Parasitic Disease

As in other classes, the role played by parasites is very difficult to estimate on post-mortem examination, and many reports are included under this heading because parasites were the sole finding. In addition, during the second period reviewed and possibly also during the first period, blood examination and microscopic examination of intestinal contents has not been employed as a routine, and doubtless some cases of parasitism have been overlooked.

The cases as analysed in Table E show, however, the following frequency of affection of the principal orders:-

Accipitriformes	-	9.3 per cent
Anseriformes	-	8.7 " "
Galliformes	-	7.5 " "
Passeriformes	-	3.4 " "
^h Sphenisciformes	-	2.6 " "
Psittaciformes	-	very small.

i.e., counting only those cases in which parasitism was the principal finding. If, however, the analysis included all cases of parasitism whether pathogenic or not, this would cause Sphenisciformes to assume probably the highest position in the table and Galliformes also to be higher. The arrangement would then be as it would be expected to be, that is, those orders receiving animal food, or having access to ponds or natural environment being more frequently affected than the orders

feeding on grain and confined in cages with hygienic floors.

Other points worthy of note are:-

- i. The apparent frequency of haemosporidial infestation in two species of birds, Touracos and Crowned Cranes, and its infrequency in other species. There may be a natural susceptibility in these two species, or some other factor may be involved, but it seems probable that once having discovered haemosporidia in these birds investigators have looked again when the species has come to post-mortem examination, and that thorough search would reveal it in other tropical birds.
- ii. The limitation of *Heterakis* species to Anseriformes and Galliformes.
- iii. The variety of parasites infesting the Galliformes compared to the other orders.
- iv. The renal trematodes affecting the Sphenisciformes (see later section). These have recently been found in Penguins at London (Osman Hill, 1952).

Weidman (Fox, 1923) gives a detailed analysis of parasitism occurring among birds at Philadelphia. His figures are not easily compared with the writer's as they include all cases of parasitism pathogenic or not, and are divided into incidence in the various families. There would appear to have been a much higher incidence of parasitism over all, however, as even excluding the smaller parasites, which were not searched for as a routine, the percentages for the principal orders are:-

Passeres	over 30 per cent
Psittacii	16 per cent
Galli	14 " "
Anseres	8.8 " "
Accipitres	6.7 " "

He states, however, that "psittac/i are on the whole not susceptible to worms," the high level being due in these figures to an outbreak of spiropteriasis. In addition, filaria are frequently mentioned, of which but few cases have been seen at Edinburgh. He quotes Plimmer's work at London and gives a short tabulated analysis of the combined figures of Philadelphia and London collections which indicates the level of avian blood parasitism to be about 6.5 per cent over all, the total level of parasitism in birds being 14 per cent.

Hamerton's figure of 2.0 per cent is much lower than the writer's, but probably indicates the use of different criteria in the estimation of pathogenicity.

Rewell (1948e) states that Haemoproteus and Leukocytozoon are common in captive wild birds and of no significance. and Worth Ratcliffe (1951b) describes Toxoplasmosis as being responsible for approximately 1 per cent of deaths at Philadelphia.

Neoplasia

It is interesting to note that only two orders show any appreciable frequency of neoplasia, Psittaciformes and Galliformes. In the former, five of the seven cases are Budgerigars and in the latter, five of the six are domestic fowls. Little attempt was made in either period to discover the nature of the neoplasms, although the organs principally affected were ovary, kidney and liver in that order. The fact that members of these two orders have perhaps the longest life of all captive birds may have some bearing on the incidence of neoplasia.

Fox (1923) remarks that "The Psittac/i are very prone to have tumours in the renal area," and his figures place this order at the head of the list of affected avian orders by a

considerable margin. Galli, however, show only one case. The high level in the Psittacii was due mainly to a high incidence in the Undulated Grass Parrakeet, nowadays more commonly known as the Budgerigar. The total incidence of 1.23 per cent of 5365 is strikingly similar to the writer's figure of 1.21 per cent of 1243 birds.

Ratcliffe (1932b), continuing Fox's study, found Psittaciformes and Galliformes the orders most frequently affected and the total incidence to have increased to 1.34 per cent. Osman Hill (1952) reports renal sarcomata in two Budgerigars at London.

Hamerton's figure, Table E, is only 0.4 per cent of "tumours and cysts" but these are presumably those cases considered fatal.

Tuberculosis

There is obviously from Table E a very great difference between the orders in their apparent susceptibility to tuberculosis, the figures for the principal orders being:-

Galliformes	-	39.4	per cent
Accipitriformes	-	16.0	" "
Anseriformes	-	7.8	" "
Passeriformes	-	very small	
Psittaciformes	-	" "	
Sphenisciformes	-	none.	

Most of these cases occurred during the war years. It would seem that the Pheasant and Buzzard aviaries and certain of the duck ponds became infected and that fresh birds were continually placed in them without adequate attempts at disinfection. The Pheasants occupy divisions of one large aviary and this therefore accommodates a fairly large number of birds at one time,

which could readily infect one another through being moved about. The figure of four cases in the Ratitae is relatively high and also occurred at a similar time, but the total number of deaths is, of course, too small to serve statistically.

A large number of reports give no details of distribution of the lesions and this prevents any discussion such as is given by Fox for the various orders. No cases of the skin tuberculosis which he describes have been seen or reported at Edinburgh. His figures for the percentages of the principal orders affected are given as

Columbae	-	32	per cent
Galli	-	14	" "
Psittac gi	-	5.4	" "
Anseres	-	5	" "
Accipitris	-	5.6	" "
Striges	-	4.5	" "
Passeres	-	1.3	" "

which places Galliformes high up, although this is stated to be due in the main to Brush Turkeys and South American Crocidae, not to Pheasants. Fox's figure of 6.2 per cent incidence over all birds is not dissimilar from the writer's 7.8 per cent.

Hamerton's figure for London (Table E) is considerably lower at 3.3 per cent. His period 1929-38 did not include war years and the consequent danger of dietary lack, and the birds at London may be housed on more hygienic floors.

Ratcliffe (1946) discusses the incidence of the disease among birds at Philadelphia and concludes that there is strong evidence that in certain groups of birds, a reduction in the incidence of tuberculosis has been due to the replacement of grain with a balanced mixed diet.

Special Diseases

Even excluding the Sphenisciformes, mycosis is the most frequent type of disease included under this heading, 26 of the 69 cases other than Penguins being mycotic disease. Apart from one case of infection with *Monilia albicans*, the majority of the remainder have not been identified but were probably *Aspergillus fumigatus* infections in the main. The distribution of mycotic affection among the orders was:-

Passeriformes	6
Galliformes	5
Accipitriformes	4 (+ 1 with concurrent tuberculosis)
Psittaciformes	4
Anseriformes	2 (+ 1 Moniliasis + 1 Mycosis associated with strep.sept.)
Alciformes	2
Pelecaniformes	2
Strigiformes	1
Other orders	None

The remaining 42 cases are made up of

- a) Fowl leukosis Complex 10 cases
(Pass. 3, Ans. 3., Galli., Pici., Strig. Pelican 1 each)
- b) Salmonella infection 8 cases
(Psittacif. 3, Gallif. 3, Anserif. 2)
- c) Pasteurella infections 3 cases
(Passerif. 2, Pelecanif. 1.)
- d) Haemolytic Group C. Streptococcus septicaemia 1 case
(Anseriformes)
- e) Other suspected septicaemic conditions 20 cases
(Passerif., Psittaccif., Accipitrif., Anserif., Columbif., Gallif., 3 each. Picif., Strigif. 1 each)

It is obvious from these figures that, apart from mycosis in Penguins, which is discussed in the section which follows, Edinburgh zoological garden has been remarkably free

from infectious diseases other than tuberculosis among birds during the periods reviewed. Although some cases may have been overlooked, there can have been nothing of epidemic proportions which is surprising as birds are seldom kept singly and the occurrence of one or two cases of Salmonellosis, for instance, would lead one to expect others. (c.f. *Pasteurella pseudotuberculosis* infection in 1952, Appendix). The numbers of cases of each disease is so small that there seems little point in attempting to discuss them further. Doubtless the high level of nutrition and hygiene enjoyed by the birds at Edinburgh is connected with the low incidence of infectious disease, and the practice of splitting the birds into small groups may also be concerned with this.

Comparison with Fox's remarks is not of much value here as at the time "Disease in Captive Wild Mammals and Birds" was written, the etiology of many diseases was still in doubt. His remarks regarding mycosis are mentioned in the following section devoted to Penguins, few of which birds had been possessed by the Philadelphia collection at that time, and he does not give a figure for the overall incidence of the disease in birds, although he gives that for water birds as 5.4 per cent compared to 3.7 per cent in land birds.

Hamerton (1939) gives a figure for mycosis of 4.1 per cent of all Aves, but not for other avian diseases apart from tuberculosis. This figure for mycosis is remarkably similar to that for mycosis alone at Edinburgh, which amounts to approximately 4.3 per cent including the Sphenisciformes.

Mycosis in many varieties of birds is mentioned in the reports of Hamerton, Rewell, Osman Hill, Fox, Ratcliffe, etc., and Fox (1937) refers to it as "that odd infection for which there is no adequate explanation." Ratcliffe (1950) suggests

that resistance to the infection may be influenced by diet. Ainsworth and Rewell's paper is referred to in the following section devoted to Penguins. Area-Leao (1948) describes two cases in Violet Tanagers, the illustrating photographs showing conidia in the airsac tissue.

Other diseases of interest reported elsewhere are:-
At London, *Salmonella typhimurium* infection in Penguins (Osman Hill, 1952), Anthrax in Eagles (Hamerton, 1942), Psittacosis in many Parrots and affecting a member of the staff (Hamerton 1939), and a severe outbreak of Botulism among Ducks and Geese at Philadelphia (Ratcliffe, 1950).

Violence

There is a surprising similarity among four of the six principal orders regarding the number of reports concerning injuries as the principal finding, i.e.,

Anseriformes	-	15.5	per cent
Passeriformes	-	14.7	" "
Psittaciformes	-	14.4	" "
Accipitriformes	-	13.3	" "

the two least frequently affected being

Galliformes	-	6.9	per cent
Sphenisciformes	-	only 1 case.	

Little discussion is possible as the factors concerned are so diverse, but broadly speaking the Anseriformes are liable to injuries from rats, etc. due to occupying open paddocks; Psittaciformes and Accipitriformes are aggressive birds which frequently attack and kill one another, and Passeriformes are small birds easily frightened and are frequently found to have injured their thin skulls by flying into stationary objects as well as dying by fighting.

Hamerton's figure of 22.6 per cent (Diagram 4) seems to be very high indeed and may in fact be due to keeping birds together in large mixed groups.

Inconclusive, etc.

This very large number of 288 reports includes members of all orders and to some extent spoils the reliability of all other figures in the analysis. However the Passeriformes and the Psittaciformes make up 171 of these reports between them. The principal reasons are in the former, the many small tropical finches not submitted for examination during Period 2, all being of one shipment and dying during the writer's absence, and for the latter, indeterminate reports during Period 1.

Hamerton's figure of 5.3 per cent 'not ascertained' is very small by comparison, but he includes 12.4 per cent 'killed by order' and gives no analysis of the diseases affecting these.

New Arrivals : Old Stock

78 of the former compared to 145 of the latter, excluding order Passeriformes, during period II. This is partly due to the infrequency of breeding and the small number of nestlings hatched, and may also indicate that birds are well suited to captivity.

TABLE DANALYSIS OF DEATHS IN THE AVIAN ORDERS

AVES.

AVIAN GROUP.	CARINATAE.																														RATITAE.																																
AVIAN ORDER.	PASSERIFORMES.	PICIFORMES	COCYBIGIFORMES	CORACIIFORMES	PSITTACIFORMES.	STRIGIFORMES	ACCIPITRIFORMES	PELECANIFORMES.	PALAMEDEIFORMES	PHENICOPTERIFORMES	ANSERIFORMES.	ARDEIFORMES	BALEARICIFORMES	CHARADRIIFORMES	LARIIFORMES.	ALCIFORMES.	SPHENISCIFORMES.	PODIPIDIFORMES	RALLIFORMES.	COLUMBIFORMES	GALLIFORMES.	CASUARIFORMES	RHEIFORMES	STRUTHIONIFORMES.																																							
PERIOD.*	P ₁	P ₂	P ₁	P ₂	P ₁	P ₂	P ₁	P ₂	P ₁	P ₂	P ₁	P ₂	P ₁	P ₂	P ₁	P ₂	P ₁	P ₂	P ₁	P ₂	P ₁	P ₂	P ₁	P ₂	P ₁	P ₂	P ₁	P ₂	P ₁	P ₂	P ₁	P ₂	P ₁	P ₂																													
CARDIO-VASCULAR SYSTEM	1	.	.	.	.	.	1	.	2	.	1	.	1	.	1	.	2	.	.	.	2	.	2	.	2	.	1	3																					
RESPIRATORY SYSTEM	30	16	.	.	3	.	.	.	46	.	.	.	3	2	.	3	.	.	.	1	.	2	.	1	3	6	.	6	.	2	1	.																							
ALIMENTARY SYSTEM.	15	13	2	.	6	.	7	2	34	1	1	9	1	2	12	.	2	.	2	1	1	10	.	5	1	2	.	1	2	.	9	.	.	.	1	10	2	14	.	3	9	.	4																				
URINARY SYSTEM	2	2	1	.	.	.	1	.	8	.	6	1	1	8	2	2	.	.	3	9	.	3	6	.	5	1	.	1	.	1	1	1	1	10	2	4	.	1	.	1	.	6	.	.	.																		
REPRODUCTIVE SYSTEM.	2	4	1	.	11	.	6	.	1	5	1	1	.	.	1	1	1	.	.	2	.	3	.	1	.	.	.																				
NERVOUS SYSTEM.																			
OTHER TISSUES	.	1	1	1	1																				
DIETARY DISEASE AFF. THE SKELETON.	1	.	1	1	.	1																				
OTHER DIETARY DISEASE.	3	1	.	1	.	.	.	4	.	1	1	.	.	3	9	.	1	1	.	1	.	1	.	7	.	1	1	.	.	.																				
PARASITIC DISEASE.	9	.	.	.	8	.	1	.	1	.	1	.	7	9	.	.	.	7	4	.	3	3	.	11	.	1																				
NEOPLASIA.	1	.	.	.	1	.	.	.	6	.	1	6																				
TUBERCULOSIS	2	1	.	.	.	1	.	9	3	2	.	.	.	8	.	.	.	3	1	.	6	3	.	4																				
SPECIAL DISEASE.	12	2	1	.	1	.	.	.	9	.	1	3	.	7	.	3	1	1	1	9	.	1	1	1	.	33	15	3	.	.	3	.	11	.	1	.	.	.																			
VIOLENCE.	10	29	.	.	2	.	4	1	.	19	1	13	7	2	2	6	2	3	4	.	.	4	4	8	3	.	1	2	1	.	.	.	1	.	7	4	.	7	1	.	.																	
INCONCLUSIVE, ETC.	38	74	2	.	4	1	.	1	.	52	1	6	4	3	2	7	.	1	.	3	1	.	12	4	3	.	6	1	2	.	.	1	2	1	1	1	.	9	.	5	13	.	3	.	.																		
TOTALS.	125	141	6	0	0	25	1	4	15	0	2	19	0	3	36	25	8	5	6	1	6	8	15	1	5	3	4	2	4	7	14	18	21	2	13	18	2	4	2	2	0	3	3	2	10	5	1	80	28	8	1	2	1	1	39	0	14	141	0	19	19	0	4
	125	141	6	0		25	5	15	2	19	0	39	25	13	61	14	15	6	3	4	6	71	32	21	15	18	6	2	2	3	5	10	6	80	36	1	2	2	39	14	144	19	19	4																			
	266		6			30		17		229		38		75		21		3		10		103		36		24		4			8		16		116		1		4		53		160		23																		

* P₁ 1938-49.
P₂ 1950-51.
N.A. Bird in the park less than 6 months.
O.S. " " " " more " " " .

GRAND TOTAL. 1243.

TABLE E.

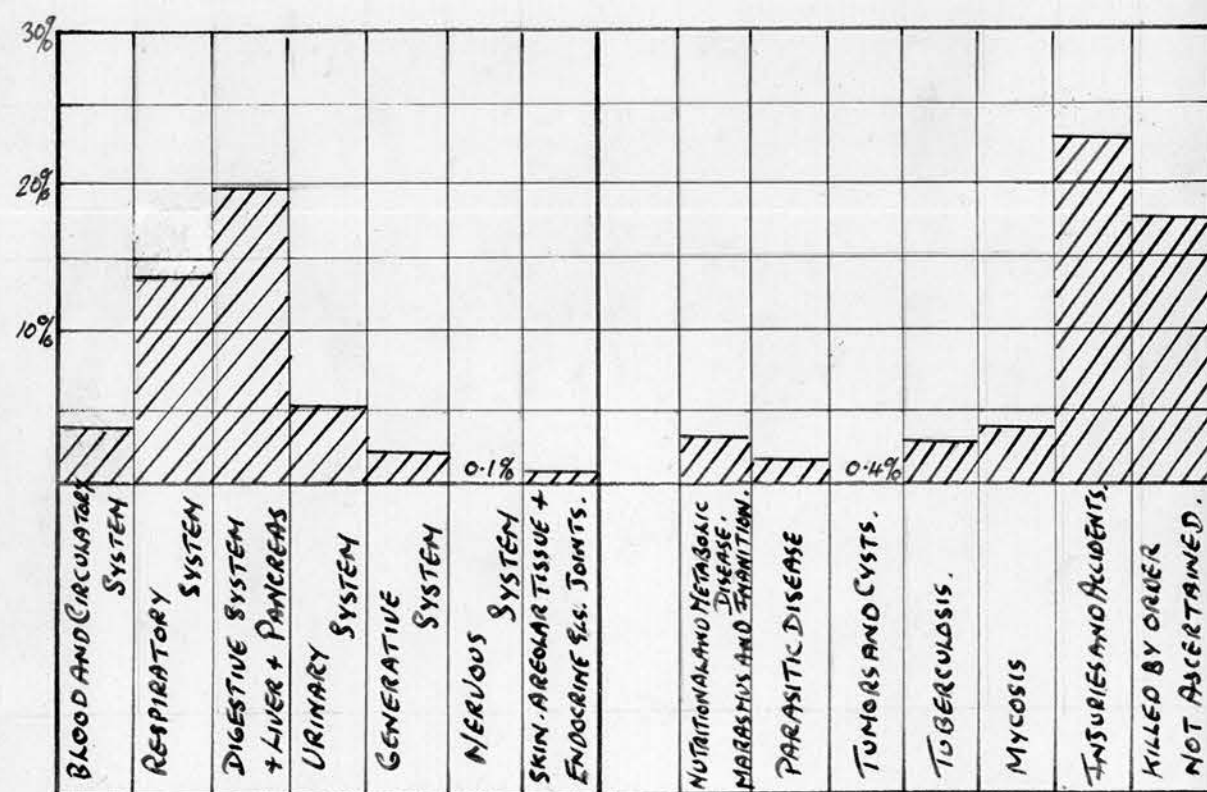
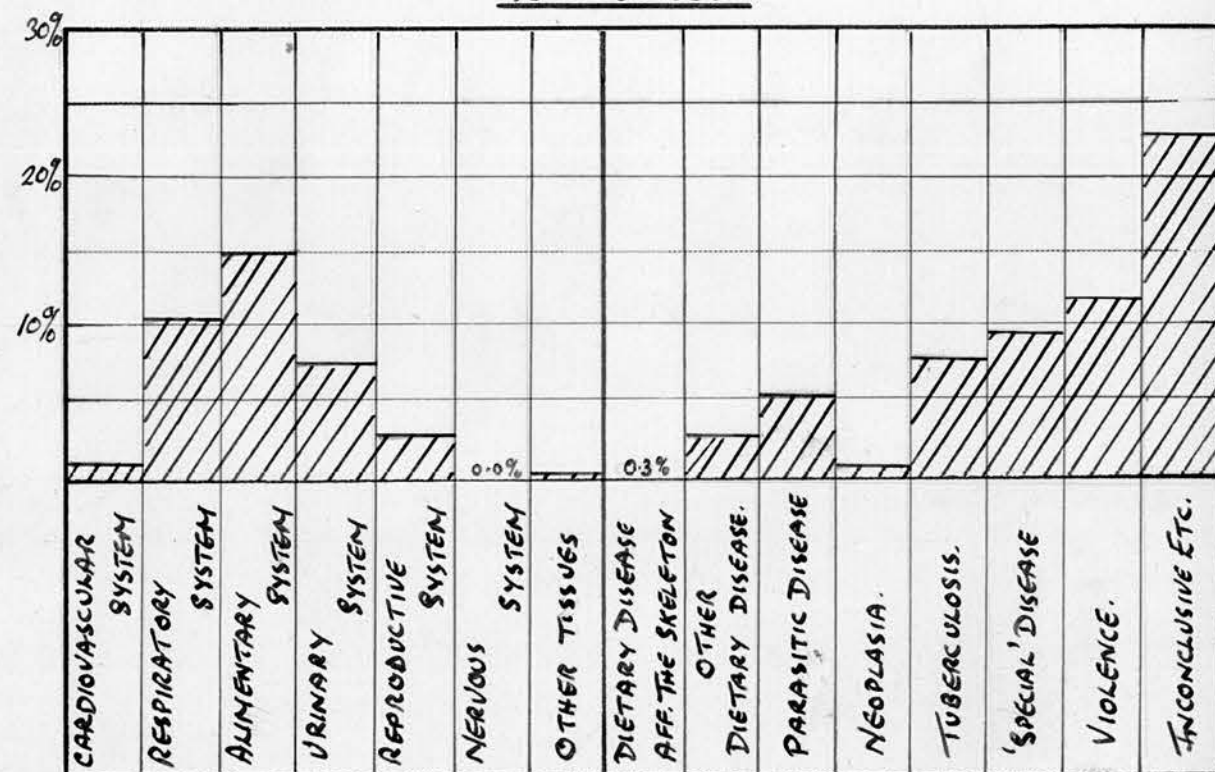
COMPARISON OF THE SIX PRINCIPAL AVIAN ORDERS.

COMPARISON WITH LONDON.

	PASSERIFORMES		PSITTACIFORMES		ACCIPITRIFORMES		ANSERIFORMES		SPHENISCIFORMES		GALLIFORMES		TOTAL PERIOD I.	* NEW ARRIVALS PERIOD II	* OLD STOCK PERIOD II	TOTAL.	PERCENTAGE.
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%					
CARDIOVASCULAR SYSTEM.	1	0.4	3	1.3	1	1.3	.	.	2	1.7	3	1.9	16	.	2	18	1.4
RESPIRATORY SYSTEM	46	17.3	46	20.1	3	4.0	2	2.0	4	3.4	8	5.0	104	3	2	125	10.1
ALIMENTARY SYSTEM.	28	10.5	36	15.7	12	16.0	10	9.7	9	7.8	17	10.6	148	8	18	187	15.0
URINARY SYSTEM.	4	1.5	14	6.1	10	13.3	12	11.7	16	13.8	6	3.8	58	5	26	91	7.3
REPRODUCTIVE SYSTEM.	6	2.3	17	7.4	.	.	7	6.8	1	0.9	4	2.5	25	1	11	41	3.3
NERVOUS SYSTEM	0	-	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.
OTHER TISSUES.	1	0.4	1	0.4	1	1.3	1	1.0	.	.	1	0.6	4	.	2	7	0.6
DIETARY DISEASE AFF. THE SKELETON	0	.	0	.	1	1.3	.	.	.	.	1	0.6	3	1	.	4	0.3
OTHER DIETARY DISEASE	3	1.1	1	0.4	4	5.3	12	11.7	7	6.0	.	.	18	19	.	37	3.0
PARASITIC DISEASE	9	3.4	1	0.4	7	9.3	9	8.7	3	2.6	12	7.5	64	.	1	66	5.2
NEOPLASIA	1	0.4	7	3.1	.	.	.	.	.	.	6	3.8	14	.	1	15	1.2
TUBERCULOSIS	2	0.8	1	0.4	12	16.0	8	7.8	.	.	63	39.4	93	.	4	97	7.8
'SPECIAL' DISEASE.	14	5.3	10	4.4	7	9.3	10	9.7	51	44.0	12	7.5	94	17	7	120	9.7
VIOLENCE	39	14.7	33	14.4	10	13.3	16	15.5	1	0.9	11	6.9	59	15	45	148	11.9
INCONCLUSIVE ETC	112	42.1	59	25.8	7	9.3	16	15.5	22	19.0	16	10.0	176	9	29	288	23.2
TOTALS.	266	100.	229	100	75	100	103	100	116	100	160		676	78	148	1243	100

* Excluding Passeriformes.

EDINBURGH.



LONDON.

Drawn from the figures of Hamerton (1939)

SECTION C

A SURVEY OF DISEASE AMONG PENGUINS AT
EDINBURGH ZOOLOGICAL PARK DURING THE

PERIOD 1917-51

WITH PARTICULAR REFERENCE TO MYCOSIS

INTRODUCTION

Table I is an analysis of the post-mortem findings in 326 birds dying at Edinburgh Zoo between 1915 and 1951. For the period 1915-1937 the only record now available is a 'Death Book' where the diagnosis is limited to a few words and is sometimes missing altogether. For the period 1937-49 post-mortem reports are available, and for 1950 and 1951 ~~one of the authors~~ has been responsible for post-mortem examinations. For the purposes of clarity the findings from all three sources have been added together in Table I, but figures for the separate periods are appended.

The post-mortem findings have been classified with care in an attempt to present them in as logical a manner as possible. Each bird is included under one heading only as it is felt that the introduction of "secondary" findings in a table based on incomplete data renders the whole valueless. Where not of a generalised nature, bacterial infections are included under the anatomical region and reference is made to them in the text.

MYCOSIS

As can be seen from Table I, 113 of the 326 adult penguins dying between 1915 and 1951 were reported as showing mycotic affection of the respiratory tract. In addition, two cases of hepatic and one of renal affection were reported making a total of 116 or 34.3% of all adult penguin

TABLE I

POST-MORTEM FINDINGS IN ADULT PENGUINS
AT EDINBURGH ZOO
During the Years 1915-51 (inclusive)

Diseases of the;-

<u>CARDIO-VASCULAR SYSTEM</u>	...	...	3
<u>RESPIRATORY SYSTEM</u>			
Mycosis, considered to have caused death			101
Mycosis, slight or associated with other possible causes of death	...		12
Other affections	...	...	6
<u>ALIMENTARY SYSTEM</u>			
Obstructions	...	...	11
Gastritis	...	...	12
Enteritis	...	...	8
Hepatic affections	...	...	7
<u>URINARY SYSTEM</u>			
Kidney affections	...	...	26
<u>REPRODUCTIVE SYSTEM</u>			
Prolapse of oviduct	...	...	1
<u>GENERALISED INFECTIONS</u>			
Bacterial	...	...	9
Viral	...	...	1
<u>VIOLENCE and INJURIES including "Bumblefoot"</u>			9
<u>SENILITY as probable cause of death</u>			1
<u>INCONCLUSIVE, DOUBTFUL DIAGNOSIS, MISSING REPORTS, ETC.</u>		...	119
<u>TOTAL</u>	...	...	326

deaths. In the vast majority of these cases mycosis is considered to have been the principal cause.

Unfortunately it is not known how frequently the diagnosis was confirmed by histological or cultural methods during the 1916-37 period as the original reports are not available. During the period 1938-49, nine of the 33 cases are known to have been confirmed by cultural means. For the 23 cases in 1950 and 1951, 16 were confirmed histologically, 2 culturally, 2 were negative culturally and 3 not confirmed.

Considering the known susceptibility of penguins to the disease, however, and the characteristic nature of the symptoms and post-mortem findings, it is felt that the figures shown in Table I are reasonably accurate, despite the fact that a number may not have been confirmed. Indeed it is probable that, especially for the period 1915-37, the figures are an under-estimate as a number of carcasses, classified as missing in Table I, were reserved for anatomical and museum specimens and thus not submitted to a pathologist's examination (see Table IV appended).

Comparative figures among penguins elsewhere are not available since Edinburgh is in a unique position regarding these birds, but reference is made by several pathologists to small numbers of penguins.

The 116 cases of infection have been divided among the species of penguins kept as in Table II.

TABLE II.

THE PERCENTAGE OF DEATHS DUE TO MYCOSIS IN THE
SPECIES KEPT AT EDINBURGH
During the Period 1915 - 1951

Species	No. of Deaths	No. of Cases of Mycosis	Mycosis as Percentage of Deaths
KING	76	27	35.5% (± 16.7)
GENTOO	72	21	29.2% (± 16.1)
RINGED	87	43	49.3% (± 16.1)
ROCKHOPPER MACCARONI	49	9	19.4% (± 17.0)
BLACKFOOT	29	8	27.5% (± 24.9)
OTHERS	13	8	-
TOTAL	326	116	32.5%

Note The figures in parenthesis are the standard of error multiplied by three, giving a 99% level of chance variation.

Because the figures available for any one species are small, the standard of error of the percentages is high, and in consequence statistically there is shown to be no significant difference in susceptibility between the species at a 99% level of chance variation. This does not exclude the possibility of such a difference existing, however, and the

table is included because at least it does not contradict the firm belief held among zoo staff at Edinburgh^{and elsewhere} that the King and Ringed Penguins have the highest susceptibility to mycosis, and the Maccaroni and the Blackfoot the lowest susceptibility. If this difference does indeed exist it may be explicable on the grounds of natural distribution. The King and Ringed species have a limited habitat near the South Pole, that is in an area where there is supposed to be little opportunity for them to develop immunity to mould infection, whereas the Blackfoot and Maccaroni penguins have a wider and more northerly distribution in nature. (Walker (1941) comments on the ability of the Blackfoot Penguin to thrive in temperate climates.)

The species included under "Others" are three Magellans, two Fairy Penguins and three where no species is mentioned. The Fairy Penguins are included despite lack of confirmatory evidence (see below) and mention is made here of them because it has been stated that they are immune to the disease. This statement is interesting for the Fairy Penguin is another northerly distributed species.

The Disease during the period 1950-51

Only three deaths were associated with mycotic infection during 1950. Two of these were new arrivals, a King and a Gentoo Penguin, and one was an old King Penguin which had been in the Zoo for some years. This last was the only Penguin to die from the disease in our established breeding colony during these two years. It had recently undergone (vide Gillespie 1938) the strain of feeding a chick. Diagnosis rests

upon symptoms and macroscopic findings only in the two King Penguins. It was confirmed in the case of the Gentoo by the culture of an *Aspergillus*, not apparently *Aspergillus fumigatus*.

The remaining 20 cases occurred during the spring and summer of 1951, sixteen of them in one consignment of 41 Ringed Penguins which arrived on the 9th of April 1951. Many of these birds were in thin condition and did not feed readily.

The first six deaths occurred within three days of arrival, the birds showing no symptoms other than regurgitation of partly digested fish. Post-mortem examination revealed one or two firm pea-sized lesions in the lungs in five of the birds, in one of which there was a small discrete colony of fungus growing in an abdominal airsac. Four of these were definitely confirmed by the discovery of hyphae on histological examination, and one almost definitely. The sixth showed no signs of mycotic infection.

Thus in the first five deaths where mycotic infection was found, it cannot be taken to be the principal cause of death. This was almost certainly malnutrition coupled with the change of environment.

The following five deaths occurred between the seventh and ninth day after arrival. Symptoms were not pronounced but mycotic infection involved both lung and airsac tissue in each case and all were confirmed by histological discovery of fungal hyphae.

The twelfth bird died from another cause.

The remaining six deaths were spread over a

period of several weeks, the last dying on 21.6.51. All showed pronounced symptoms and the period between the commencement of these and death varied from about five days to several weeks. Usually some reluctance to feed was the first symptom, after which the respirations became increasingly laboured until the bird spent much of its time when the head thrown back, the beak partly open and the whole region of the chest between the clavicles rising and falling in a most striking manner. The sound emitted was loud enough, even in this small species, to be heard some distance away. In the early stages, before the respiratory symptoms became obvious, there was sometimes a faint wheezing or an occasional cough and characteristic shake of the head.

K.L.Bullis

As an interesting point of comparison, ⁽¹⁹⁴³⁾Biester and Devries state that in domestic birds the laboured respirations occasioned by mycosis are usually silent. This is certainly not so in the Ringed or King Penguins.

Lesions in these final six cases were again widespread involving the lungs and airsacs to a varying extent. All six were confirmed, five by histological demonstration of hyphae, one by cultural methods, the growth being identified as *Aspergillus fumigatus*.

The other four cases were two Fairy Penguins, one Blackfoot Penguin and one King Penguin.

The Fairy Penguins arrived on the 8th April, 1951, and occupied an enclosure adjacent to the

Ringed Penguins. They died on the 19th and 20th July 1951 respectively, after showing laboured respirations for some days. On post-mortem the picture was typical of mycotic infection with caseating masses in lungs and airsacs. Smears and cultures, however, proved negative and unfortunately no tissue was kept for histological examination. These can only be classified as 'probables', therefore, especially in view of the statement, referred to above, that Fairy Penguins are immune to the disease / ("Bander Log" 1949) It is the opinion of the writer, however, that these birds were affected with mycosis.

The Blackfoot Penguin was an old bird sharing an enclosure with the Ringed Penguins. Diagnosis here was limited to macroscopic appearances.

The King Penguin was a sporadic case among the year's new arrivals which were kept separate from the Ringed. Macroscopic findings were characteristic but gave negative cultures. Confirmation was obtained by the detection of hyphae. This group of King Penguins numbered 29, all of which were in good condition on arrival and this was the only case of mycosis among them.

POST-MORTEM FINDINGS

Situation of Lesions

In 113 of the 116 cases of mycotic infection the principal lesions were situated in the respiratory tract. An attempt was made to analyse the reports and estimate the comparative frequency of infection

of lungs and airsacs but the information available was insufficient.

The respiratory tract was the main part of the body affected in all 60 cases occurring during the 1915-37 period and in 56 of these mycosis was considered to be the cause of death. In the remaining four cases it was associated in two with impaction of the alimentary tract and in one with a so-called abdominal tumour. The fourth case was reported as 'slight'.

During the 1938-49 period, three of the 33 cases were reported as showing the principal mycotic lesions elsewhere than in the respiratory tract. Growths of *Aspergillus fumigatus* were obtained in culture from heart, liver and gall bladder in the first case, from liver and intestine in the second case and from the kidney and respiratory system in the third case. The report makes specific mention of culturing the actual liver substance, but the kidney affection may have been superficial. Of the nine positive cultural examinations during this period mentioned above, all revealed *Aspergilli*. The three cases where mycosis was not the sole finding were associated with nephritis.

As mentioned above, all 23 of the cases during 1950-51 showed principal lesions in the respiratory tract but in a number of the Ringed Penguins there were small firm nodules in the intestinal wall. These appear mycotic on histological examination but hyphae have not been demonstrated. On one occasion a mycotic growth was cultured from the intestinal contents.

Naked Eye Appearance of Lesions

The most typical picture showed small caseous nodules scattered evenly throughout the lung substance but these were sometimes confluent and in one case were absent. The airsacs showed isolated "button" colonies with a superficial "furry" growth of mould in some cases. In others the entire airsac wall was covered with dense white material to a thickness of a centimetre or more, and the whole could be "shelled out" as a perfect cast of the sac with a hollow centre. The isolated colonies were most commonly encountered in the anterior airsacs, the widespread deposit in the posterior.

The lesions in Penguins do not seem to differ greatly from those found in other species of birds as described by Ainsworth and Rewell ⁽¹⁹⁴⁹⁾ except for one or two points. They state that the infection of the lung is rarely found alone, and it is the generally accepted opinion that the reason for the susceptibility of birds to mycotic infection is that the airsacs provide an ideal medium for growth. In four of the first five Ringed Penguin deaths mentioned above, however, one or more lung nodules were present without any apparent airsac affection. Minute colonies may have been overlooked, but at least the lung affection must have been more or less simultaneous with, if not preceding, that of the airsacs. Secondly, in Penguins, the abdominal airsacs were almost invariably more heavily affected than the cervical and thoracic, and thirdly free fluid has been found within sacs heavily coated with mycotic growth.

HISTOLOGICAL APPEARANCE

Fox (1923) and Ainsworth and Rewell (1949) agree in their description of two principal types of lesion in the avian lung:-

1. An ill-defined consolidation.
2. A "granulomatous", "tubercular" or "mycetomatous" type later taking on the appearance of a chronic abscess.

The material of these workers was in both cases drawn from a wide variety of avian species including some penguins.

Sixteen of the seventeen cases examined histologically by the present author were Ringed Penguins from the same flock and died within a short period of each other. In some of these cases the first type of lesion can be seen and in others the second type; but both types appear to arise in a similar manner, as a nodule in the wall of a tertiary bronchiole.

The ill-defined type of lesion appears to be infiltrative and to consist of entangled hyphae and dead or dying heterophils and mononuclear cells. The hyphae frequently grow out into the bronchiole and can then be readily recognised as palely basophilic, straight, septate, branching rods, even under low magnification. Where this does not occur they may be difficult to detect except where they ramify at the edges of the lesion. Conidia have been seen in few cases but their appearance, when present, is unmistakable. The surrounding lung tissue has invariably shown intense congestion, some collapse

and infiltration with many heterophils. The impression is gained that this type of lesion is spreading rapidly, surrounding and obliterating the tertiary bronchioles and forming large necrotic areas.

The second type of lesion appears much more circumscribed. Hyphae are frequently difficult to demonstrate, the mass consisting mainly of cell debris surrounded by macrophage type cells. The central area may undergo further disintegration appearing as an acellular acidophilic mass. The surrounding lung tissue is much less congested and fewer heterophils can be seen. Also some fibrous elements appear to surround the lesion in some cases. This type of lesion would appear to be less progressive than the first, perhaps due to an increased resistance on the part of the bird, to a reduced virulence on the part of the infective agent, or to other factors.

As noticed by Ainsworth and Rewell, but apparently not by Fox, large multinuclear giant cells have been encountered.

The airsac lesions have been less thoroughly studied but appear to follow Ainsworth and Rewell's description closely. As in the lung lesions, hyphae are not always easily detected.

Treatment

Attempts at treatment have been made in the past and are still being made but so far without success. Gentian violet as a 1% aqueous solution injected into the abdominal airsacs was employed by previous workers. The present author during the

last year have used "Penotrane"^{*} 10% solution by stomach tube in the heavy dosage of $\frac{1}{2}$ ounce twice daily, the use of which was first suggested by Dr. C. Horton Smith of the Animal Health Trust.

Poultry Research Station. In Ringed Penguin No.14 of the above-mentioned series this dosage was given for ten days. On post-mortem examination an unusual finding was an area of airsac wall which resembled a piece of tarred paper adjacent to the alimentary tract, whilst the outer wall of the sac was covered in the heavy white deposit typical of the disease. It seems possible that sufficient of the "Penotrane" had passed through the wall of the alimentary canal to kill the fungus in this area. In one case an injection of the solution was made into the right abdominal airsac of a bird in the late stage of the disease with rapidly fatal results.

It is proposed in 1952, should a new consignment of birds arrive accompanied by more mycosis, to repeat oral "Penotrane" in association with a finely divided spray of the same substance, if a way in which the birds can be brought to inhale this spray can be devised.

The difficulty with all methods of treatment is to recognise infected birds sufficiently early.

^{*} Phenylmercuric dinaphthylmethane disulphonate, produced by Messrs. Ward Blenkinsop Co. Ltd. A description of the pharmacology of this drug is given by F. G. Waddington. (1951).

Attempts have been made previously, and by the present author, to get some indication by taking throat swabs. This has proved no reliable guide so far, but on the next occasion it is intended to use moistened swabs as the superior larynx of the penguin appears to be very dry.

Isolation of affected birds is an obvious prophylactic measure which must, of course, be taken.

As a footnote to this paragraph it may be of use to mention that the simplest form of marking birds for purposes of throat-swabbing etc. has been found to be a dab of ordinary paint on one or both "ankles". Three birds can be marked with each colour, that is left leg, right leg, and both legs. The paint wears off in time.

Discussion

The 1950-51 series of cases confirms the fact that deaths from mycosis occur mainly in newly arrived birds, only two of the 23 affected having been in the Park more than a few months. In addition the majority of birds affected were in a somewhat debilitated condition. Of 41 Ringed Penguins which arrived in poor condition 16 died showing mycotic infection. Of 29 King Penguins in good condition only one died of mycosis.

The source of infection in domestic poultry has always been considered to be the inhalation of spores from damp and musty litter. As penguins are kept in the open on sand or rock and are fed solely on fish, another source must be responsible. Dead

grass and foliage within the enclosures is one that might be considered, unless, of course, the birds become affected before they arrive here, which seems very probable. (Rewell (1948a) quotes Lillie, who states that deaths occurred among King Penguins from mycosis during their voyage to London.)

Although most factors point to the primary seat of infection being in the respiratory tract, there is a slight possibility of an initial alimentary infection and transfer through adjacent tissues to the airsacs. If this were so, there are many possible sources of infection, such as the water of the pool, the fish either themselves or via the wet wooden boxes in which they are transported, etc. All birds are fed the same fish by the same keeping staff in similar amounts and climatic conditions are similar for all. The enclosure in which the Ringed Penguin epidemic occurred is the only one in which the water was not free flowing but stagnant and although epidemics have occurred in previous years where the water has been fresh it is felt that the point is worthy of note. Another factor of possible influence is that of exercise, since the established birds are taken for a short walk round the gardens daily, and the large pool encourages swimming.

The effect of climatic conditions is not easy to assess, although there is no doubt that the appearance of the symptoms usually coincides with warm dry weather. New consignments always arrive in the Spring and as such can be expected to contract the disease during this period of the year before they have become accustomed to their new environment.

It seems probable that the increased respirations occasioned by the heat would tend to spread the fungus throughout the respiratory system, whereas otherwise the bird's innate resistance might have overcome isolated colonies of infection. In addition there may well be more mould spores in the atmosphere during dry weather, and the greater volumes of air inhaled by the birds would increase the number of spores inhaled.

Ainsworth and Rewell give an interesting discussion of the occurrence of the condition in nature, considering that it is endemic in nature and unmasked in captivity¹. It is hoped that the Royal Zoological Society of Scotland may be able to discover something about this in penguins with the co-operation of the importers, Messrs. Salvesen & Co., through whose kind offices it is hoped to obtain the carcasses of birds dying en route.

Another point of interest is that in comparison with the London and Philadelphia Zoos at least, the general incidence of mycosis in birds of all species other than penguins at Edinburgh appears to be low.

Regarding associated bacterial infections, none have been reported nor have any been encountered by this author. Careful cultural examination and the use of selective staining methods, however, were not employed in many cases.

OTHER RESPIRATORY CONDITIONS

Considering the apparently high sensitivity of the penguin's respiratory system to mycosis, it is surprising that so few cases of other respiratory conditions have been reported. The six cases considered primary were described three times as pneumonia, once as broncho-pneumonia, once as haemorrhage and once as congestion of the lungs. In addition, one Fairy Penguin dying of 'visceral gout' showed small caseous lung nodules which gave a growth of *Pseudomonas aeruginosa* on culturing.

ALIMENTARY OBSTRUCTION

Eleven cases of this have occurred during 1915-51 and they are included under a separate heading only because they have all occurred in species other than the King Penguin. This is of interest since the King is the only species kept at Edinburgh which will not pick up food from the ground but is absolutely dependent on individual hand feeding throughout its life in captivity. The causes of impaction have included a piece of india rubber, grass, feathers, etc.

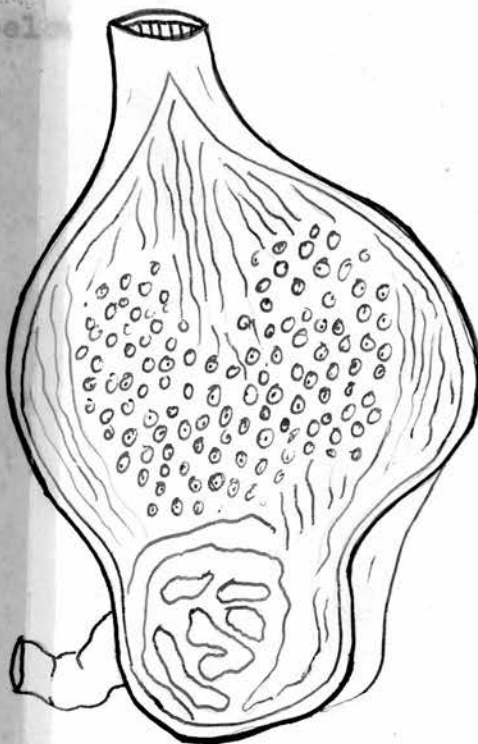
GASTRITIS

The figures in Table I include only those cases where gastritis has formed the sole or principal finding.

Various forms of gastritis have occurred in all the species of penguins kept: about twenty cases altogether, in ten of which parasites have been found

in association. These worms have been identified and as belonging to the genera *Streptocara*/*Amidostomum*.

Assessment of the degree of pathological change undergone by the mucosa has been hampered in those cases seen by the writer, because of lack of exact knowledge of the normal. It was at first thought that the 'pyloric stomach' possessed a horny lining similar to that seen in the domestic hen, as a membrane resembling a detached cuticular lining was on several occasions found applied to the stomach contents. (Reid, 1835; Watson, 1873; Waterson et al. 1915; Lowe 1933) The authorities referred to make no reference to any such thing, however. Morrison Watson's illustration has been copied diagrammatically.



THE STOMACH OF

APTENODYTES LONGIROSTRIS

after Morrison Watson

showing :-

i. "Anterior or glandular compartment" with "well defined proventricular glands"

and

ii "Muscular portion - lined by a thick but soft mucous membrane"

Parasites have never been seen in large numbers in the stomachs of penguins examined by the author, though a small number have occasionally been found partially embedded in the gastric mucosa beneath either a layer of tenacious mucus or what amounts almost to a diphtheritic membrane studded with haemorrhages.

Parasitic gastritis has been found associated with advanced mycosis at Edinburgh. It also seems related to reluctance to feed in the living birds. Portions of material have been found in enclosures occupied by healthy penguins which resemble material seen adhering to the gastric mucosa on post-mortem examination, and it is presumed that this has been regurgitated by the birds.

Fox (1929) refers to five deaths occurring in penguins at Philadelphia Zoo due to penetration of the stomach by parasitic
(See also remarks concerning penguins in the appendix referring to the year 1952)

RENAL DISEASE

After mycosis this forms the most common diagnosis on post-mortem, though it is not always easy to assess its significance in causing death. In all, kidney affections have been mentioned in reports thirty times or in nearly 10% of total cases. The frequency has been much greater during recent years either due to increased incidence or improved diagnosis. In ten of these cases visceral and/or articular gout has been associated.

Agnesia of one kidney has occurred twice in King and twice in Gentoo Penguins.

There are six mentions of 'kidney flukes' which were reported as belonging to the genus *Renicola* (Campbell 1943). Five were in King Penguins and one in a Blackfoot Penguin and all occurred during the period 1938-49. None have been found by the author but some may have

been overlooked before the importance of a thorough and careful examination of the kidneys was fully realised by him. More recently fluke infestation has been reported in Penguins' kidneys by Osman Hill (1952).

BUMBLEFOOT

This appears to have been of fairly frequent occurrence at one time though few cases occur at present. It is mentioned on one or two occasions as being sufficiently severe to involve the tendon sheaths.

BACTERIAL INFECTIONS

Various sporadic generalised infections have been reported, the significance of which is not always known. They include one case each of septicaemia due to 'enterococci' and streptococci, and two due to *B. proteus*. *B. morgani* was isolated from one case of enteritis and *B. pullorum* from another where it was also present in the ovary.

In addition the only report of tuberculosis in the whole series was an hepatic lesion in a Blackfoot Penguin. One other liver abscess is also reported.

VIRUS INFECTIONS

The only case discovered was of Erythroleucosis in a Blackfoot Penguin.

SENILITY

One Blackfoot Penguin only is included under this heading in view of the difficulty of making sure in unmarked birds.

OTHER PARASITIC INFESTATIONS

OTHER PARASITIC INFESTATIONS

Mention of parasites other than those above has been few. Occasional infestations with roundworms and an unusual tapeworm do, however, occur, though none appear to have been heavy enough to be significant in causing death.

POST-MORTEM FINDINGS IN ADULT PENGUINS
AT EDINBURGH 'ZOO'
1915 - 1951 inclusive

	1915-37	1938-49	1950-51	Total
<u>Cardiovascular System:</u>	1	2	0	3
<u>Respiratory System:</u>				
Mycosis - considered sufficiently widespread to cause death	56	27	18	101
Mycosis - slight or associated with other fatal conditions	4	3	5	12
Other affections	5	1	0	6
<u>Alimentary System:</u>				
Obstruction	6	4	1	11
Gastritis	7	4	1	12
Enteritis	5	3	0	8
Hepatic affections	3	4	0	7
<u>Urinary System:</u>				
Kidney affections	3	18	5	26
<u>Reproductive System:</u>				
Prolapse of oviduct	0	0	1	1
<u>Generalised Infections:</u>				
Bacterial	4	5	0	9
Viral	0	1	0	1
<u>Violence and Injuries:</u>				
Including "Bumblefoot"	9	0	0	9
<u>Senility</u>				
As probable cause of death	0	1	0	1
Inconclusive, Report Missing, Doubtful Diagnosis, etc.	67	49	3	119
	170	122	34	326

TABLE IVPOST-MORTEM FINDINGS IN PENGUIN CHICKS
AT EDINBURGH ZOO
1915 - 1951 inclusive

<u>POST-MORTEM FINDING:</u>	<u>Number</u>
Mycosis	4
Other diagnoses	12
Inconclusive, No reports, etc.	23
	<hr/>
	39
	<hr/>

SECTION DCLASS REPTILIA

All the reptiles and amphibians are housed in glass fronted cages which are completely isolated from each other and from the public. The principal heating supply is by hot water pipes and there is auxiliary heating by means of electric radiators in many cages. Most of the cages have pools, especially those containing amphibious reptiles. The large spurred and Leopard Tortoises are, during the summer, kept in a grass paddock.

ORDER TESTUDINATA (CHELONIA)

This order includes the Tortoises, Turtles and Terrapins, nearly all of which have a shell of bony plates. The Tortoises are terrestrial in habit and vegetarian feeders. In captivity they are fed on lettuce and other green leaves and fruits. The Terrapins, Pond Tortoises and Turtles are mainly aquatic and mostly carnivorous, being fed on scraps of raw meat.

Period 1938-49

The small number of reports for this period fall under only four headings.

Parasitic Disease

One report is included here of a Tortoise with roundworm infestation of lungs and intestines.

Dietary Disease

One report included of an emaciated Tortoise.

The Alimentary System

The three reports concern a Snapping Turtle (*Chelydra serpentina*) with 'peritonitis' and an inflammatory condition of the large intestine, an Edible Turtle with gastro-enteritis and

an associated cystitis, and a Box Tortoise with an hepatic abscess.

Inconclusive, etc.

Reports concerning five Tortoises, one Terrapin, one Pond Tortoise and one Snapping Turtle are included here. Four of these are stated to have been decomposed when received.

Period 1950-51

Post-mortem decomposition frequently obscured the findings in tortoises, as it does to a lesser extent in other reptiles. This especially applies to histological examination of the tissues. Nonetheless it has been possible to carry out examinations on most of the tortoises dying and the findings have been remarkably similar almost throughout the group. The interpretation of these findings is made difficult by lack of exact knowledge of the normal appearance of the viscera, and also by the difficulty of recognising symptoms even when these are shown. The large number of deaths among Moorish Tortoises, in relation to the number kept at any one time, is explained by the practice of members of the public who present their Tortoises to the Society when they cannot get them to thrive properly in their gardens. This means that the disease picture shown by these autopsies is not strictly a "Zoo" picture at all.

In almost all the Tortoises examined there seemed to be some abnormality of the urinary system, but in nine, disease of the alimentary tract appeared to be of more fundamental importance in causing death.

Alimentary System

Spurred Tortoise (*Testudo sulcata*) CB50/58. There were membranous deposits on mucosa of stomach and intestine, the duodenum being intensely congested. The body cavity contained much fluid, and the bladder which had ruptured

either pre- or post-mortem, was large, thin-walled and contained a quantity of urate material. Bacteriological examination was negative.

Spurred Tortoise CB 50/62. Intense congestion of duodenum and a yellow friable liver. Fluid in body cavity and ruptured bladder as CB50/58. Paracolon organisms isolated from bone marrow.

Moorish Tortoise (*Testudo graeca*) CB50/67, showed identical findings to CB50/58 and 62 reported.

Bell's Tortoise (*Kinixys belliana*) CB51/38. Multiple small necrotic abscesses in liver substance which showed widespread fatty change. Bladder intact containing urine and grey viscous mass. *Proteus vulgaris* and *Proteus morganii* isolated from liver. Some roundworms seen in stomach and intestine.

Moorish Tortoise CB51/43. Abdominal cavity filled with fluid. Remains of ruptured bladder contained mass of blue-coloured uratic material. Histological examination of liver showed perivascular degeneration and of the kidneys some epithelial degeneration of secretory tubules.

Moorish Tortoise CB51/52. Showed posterior paralysis for several days preceding death. Necrotic enteritis of caudal intestine. Bladder large, flaccid and containing much urate material. A few small roundworms seen in stomach. Histological examination showed necrosis and many eosinophils in intestinal mucosa. The kidney tissue appeared normal except for some debris in the tubules and glomerular capsules. A small caseous abscess was also present under the ventral plate from which coliform and *Proteus* organisms were isolated.

Moorish Tortoise CB51/75. Much fluid and gritty green-coloured urate material free in body cavity. Bladder ruptured, remnants only seen. Fibrinous flakes adherent to intensely congested duodenal mucosa. A few small roundworms in stomach and intestine. Histological examination showed roundcell and eosinophilic infiltration of the intestinal mucosa and degenerative changes in the renal tubular epithelium. Bacteriological examination of intestine and bone marrow was negative.

Moorish Tortoise CB51/76. Sanguinous fluid and soft green uratic material free in the body cavity. Intense congestion of intestinal mucosa with many adherent fibrin flakes. Bladder collapsed and apparently ruptured. Small amounts of caseous material in joint cavities. Histological examination showed what appeared to be bacteria and eosinophils among the necrotic mucosal cells of the intestine. Kidney tubule cells were not greatly abnormal, though granules could be seen in the cytoplasm and hyaline debris was present in the lumina. A non-haemolytic staphylococcus was isolated from the bone marrow, but the intestine was negative for pathogens.

Leopard Tortoise CB51/77. Some free fluid in the body cavity. Bladder large, thin-walled, intact, empty. Liver black in colour, white spots throughout. Histological examination revealed widespread fatty change and areas of focal necrosis in liver. Many large ova were also present.

No examination was made for protozoa in any of these cases.

The Urinary System

Moorish Tortoise CB50/7. Hard dry lumps of uratic material in the bladder.

Moorish Tortoise CB50/14. As CB50/7.

Moorish Tortoise CB50/16. Off food for several days. Dosed with Potassium nitrate. Passed excrement before death. The bladder was found to be distended with liquid urates and many roundworms were seen in stomach and intestines. The kidneys were reported as normal after histological examination.

Moorish Tortoise CB50/54. Bladder distended with fluid and clots of uratic material. A few small ulcers were seen in the posterior intestinal mucosa.

Moorish Tortoise CB50/65. Distension of bladder with clear fluid and uratic 'sand.'

Leopard Tortoise (*Testudo pardalis*) CB51/18. All viscera appeared oedematous, the intestinal mucosa congested and the kidneys yellowish with concretions of urate material visible on section. Histological examination revealed multiple minute foci of inflammation in the kidneys surrounded by round cells and many eosinophils.

Moorish Tortoise CB51/22. Body cavity contained fluid and uratic 'sand'.

Moorish Tortoise CB51/32. Bladder distended with quantities of uratic 'sand.' Histological examination of the kidney showed loss of all structure due to post-mortem decomposition.

Leopard Tortoise CB51/33. Distinct uraemic odour. Small quantity of haemorrhagic fluid in abdomen. Flakes of fibrin adherent to gastric mucosa. Bladder empty, merely a tenuous membrane. Histological examination pointed to more kidney changes, including fibrosis, than would be accounted for by post-mortem decomposition.

Moorish Tortoise CB51/44. Little abnormality seen on macroscopic examination excepting hard faecal balls in caudal

intestine and a few roundworms. Joint capsules contained much uratic material. Bladder contained a little moist uratic material and no fluid. Histological examination showed casts in kidney tubules and some destruction of tubular epithelium. The liver appeared much changed from post-mortem decomposition.

Moorish Tortoise CB51/53. Bladder distended with fluid and green granular material. The kidneys, which were large and pink in colour, showed much post-mortem change but some glomeruli could be seen to have hyaline centres on histological examination.

Blanding's Turtle CB51/68. Over 15 years of age. Much decomposed. Soft shell. Only remnants of bladder tissue found.

European Pond Tortoise CB51/72. Some free fluid in body cavity and dry urate material in cloaca. Histological examination of the kidneys showed advanced degenerative change of renal tubule secretory epithelium.

Inconclusive, etc.

These were Tortoises CB50/2, 3, 30, 33; CB51/1, 40 and 50; and Turtle CB50/53.

Of these a Moorish Tortoise and a Spurred Tortoise contained a large number of well-developed ova, and the Turtle which showed paralysis for three days before death showed congested lungs only. *Proteus* sp. was recovered from the bone marrow of CB51/1 which was too decomposed for other examination.

ORDER LORICATA (CROCODYLIA)

This includes the Crocodiles, Alligators, Gavials and Geymans. They are exclusively carnivorous and amphibious.

Period 1938-49

The few reports are listed briefly as follows:-

Alligator (Alligator ?) - haemorrhagic condition of the lungs.

Alligator - foreign bodies in stomach. Emaciation.

Alligator - necrotic ulceration of the stomach.

Nilotic Crocodile (*Crocodylus niloticus*) - gastritis.

Sharp-nosed Crocodile - diphtheritic enteritis.

Nilotic Crocodile - gangrenous enteritis.

Alligator - rectal impaction and hepatic abscess.

Crocodile - tuberculosis.

Crocodile - tuberculosis.

Crocodile - water in 'airsacs' (lungs presumably)

Alligator - presumed drowned.

Mississippi Alligator (*Alligator mississippiensis*) - gangrenous cellulitis and oedema of lungs.

Nilotic Crocodile - skin necrosis of and subcutaneous haemorrhages.

Alligator - focal necrosis of liver.

Crocodile - hepatitis.

Five Crocodiles - inconclusive.

Period 1950-51

Only two deaths occurred during this period.

CB50/39, a young Crocodile drowned by its companion and

CB51/3, an Estuarine Crocodile (*Crocodylus porosus*). The latter was lightly anaesthetised with chloroform and confined in a small box for some days. It died the day after it was

returned to its pool. The principal finding was widespread hepatic fatty change. The reptile was over 20 years of age and lack of exercise during this long period of captivity may have been partly the cause of the fatty change, which was presumably accentuated by detoxication of the chloroform, although only a small quantity was used.

ORDER SAURIA (SQUAMATA - S.O. LACERTILIA)

This order includes all the many species of Lizards, which are terrestrial reptiles, invariably carnivorous and possessed in almost all cases of four legs. According to their size they are fed on meat, mealworms, fly larvae ("gentles"), cockroaches, etc. They vary in size from the monitors, which may be five feet in length to the small wall lizards.

Period 1938-49

The Cardiovascular System

One report included of a Margouillat Lizard (*Agama agama*) with myocarditis.

The Respiratory System

Included are a Teguxin (*Tupinambis teguxin*) with congestion of the 'airsacs' (presumably lungs) and a Tuberculated Iguana with congestion of the lungs.

The Alimentary System

The Intestines: A Two-banded Monitor (*Varanus salvator*) is reported with necrotic enteritis from which *B. coli* only was isolated, and a Tuberculated Iguana with enteritis.

The Liver: The six reports concern:- Hepatic abscesses in a Teguxin, hepatic degeneration in one Two-banded Monitor and a caseating condition of the liver in another. Fatty degeneration, ulceration and abscess formation in a Lace Monitor (*Varanus varius*). Hepatitis and skin lesions in a Rhinoceros Iguana (*Metapocetes cornutus*) and haemangioma of the liver in a Two-banded Monitor.

The Urinary System

One Monitor with pyaemic nephritis and peritonitis is included here.

Reproductive System

One report of a Tuberculated Iguana with impaction of the oviduct.

Parasitic Disease

A Lesueur's Water Lizard showed a 'parasitic growth obstructing the alimentary canal', a Banded Skink enteritis apparently due to 'roundworm' infestation, and Green Lizard (*Lacerta viridis*) gastritis from the same cause.

Inconclusive, etc.

Reports included are one Giant Skink, two Tuberculated Iguanas, a Green Lizard and a Chameleon (*Chamaeleon chamaeleon*) all of which were decomposed when received.

Period 1950-51The Alimentary System

The Mouth: In two Green Lizards CB50/19 and 20 necrosis of the maxillary bone was considered to have prevented feeding and resulted in death from cachexia. CB50/10, a Two-Banded Monitor showed an inflamed and 'cankorous' condition of the mouth which presumably led to death from the same cause. This reptile also had parasites somewhat resembling *Linguatula* larvae in the lungs.

The Liver: CB51/61, a Nilotic Monitor (*Varanus niloticus*) showed abnormal liver and kidneys on examination, and tapeworms in the intestine. Histological examination showed vacuolation and degeneration of many hepatic cells and an eosinophilic infiltration. Widespread degeneration of kidney tubules was also evident. Paracolon organisms were isolated from bone marrow.

CB50/4, an Eyed Monitor (*Varanus ocellatus*) was reported as dying from liver failure and a Bosc's Monitor (*Varanus exanthematicus*) CB50/47 showed widespread hepatic fatty change.

The Urinary System

The principal finding in CB51/11, a Bosc's Monitor, was 'Articular Gout', deposits of urate material being present in the joint cavities, and the kidneys being firm, yellowish and gritty on cutting. Widespread destruction of the kidney elements was seen on histological examination. A quantity of solid urate material distended the caudal end of the alimentary canal in a Plated Lizard (*Gerrhosaurus* ?) CB51/4. A similar plug was found in CB51/74 a Clawless Gecko (*Pachydactylus* ?) and deposits of uratic material were found also at the intervertebral junctions and elsewhere.

An Eyed Lizard (*Lacerta lepida*) CB51/45, showed deposition of urate material in the kidneys.

The Reproductive System

The cases included here are of reptiles which showed no major abnormality at post-mortem, but were found to be carrying well-developed eggs within the oviducts. This includes almost the whole of one consignment of Flap-Necked Chameleons (*Chamaeleon dilepis*) and the fact that so many of the group were females raises an interesting point as to mode of capture as the sexes are indistinguishable externally. One or two were emaciated, but most of them showed some fat in the abdominal depots. Dietary factors may of course be involved. Rewell (1948a) mentions similar occurrences among Chameleons.

CB50/8, a Common Chameleon and CB51/12, 13, 14, 15, 16, Flap-necked Chameleons, showed advanced hepatic fatty change in addition, CB51/19, 30, 31 and 34 also Flap-necked Chameleons showed no hepatic change, but one showed a peculiar condition of the intestines. CB50/50, a Plated Lizard, was thin and had two very large eggs in the oviduct.

Dietary Disease

One Green Lizard CB50/18, a Common Chameleon CB50/57 and seven Agama Lizards CB50/5, 1, 38, 45, 55, 56, 63 and 64 are included here as they died showing little on post-mortem examination except for occasional tapeworm and roundworm infestation of the intestine. Their diet was known to be incorrect

Parasitic Disease

CB50/46. A Nilotic Monitor was reported as showing gastritis due to deeply embedded nematodes.

Neoplasia

Neoplasia

Two Bearded Lizards (*Amphibolonus barbatus*) CB50/15 and 34, showed during life recurrent cutaneous papillomata which dropped off and then recurred in a different place. Death was probably connected with the 'cankorous' condition of the mouth and subsequent cachexia in the first one. The second was not examined post-mortem.

Injuries

CB50/1, a female Two Banded Monitor, was crushed to death by the heavy male Monitor while attempting service.

CB50/11, an Agama Lizard, showed a heavy infestation with tapeworms and the root of the tail showed a large caseous abscess which probably resulted from a bite.

Inconclusive, etc.

CB50/51, a Giant Skink, possibly senile being 11 years old, CB51/5, 9 and 10, Flap-necked Chameleons, CB51/8 a Plated Lizard and CB51/78 a Common Chameleon, were too decomposed for diagnosis.

The examination of CB51/23, a Wall Lizard (*Lacerta muralis*) was inconclusive.

CB51/64, a Gecko and CB51/67 a Sand Lizard (*Lacerta agilis*), were preserved as specimens. The Flap-necked Chameleon CB50/9 was sent to the Museum.

CB50/26, 28, 29, 48 and CB51/35 were not examined post-mortem.

ORDER SERPENTES (SQUAMATA S.O. OPHIDIA)

This includes the snakes, both venomous and non-venomous. All are carnivorous and are fed according to their size on mealworms, frogs, mice, guinea pigs, rats and rabbits. At Edinburgh, as in most zoological collections in Britain, all the mammals used, excepting new-born mice, are killed before they are fed to the reptiles.

Period 1938-49

The Respiratory System

Congestion of the 'airsacs' (presumably lungs meant) is reported six times in two Reticulated Pythons (*Python reticulatus*), one Indian Python (*Python molurus*), a Pine Snake (*Pituophis melanoleucus*), a Chicken Snake (*Elaphe quadrivittata*) and a Bull Snake (*Pituophis sayi*).

'Pneumonia' is reported in a Mole Snake and a Fox Snake (*Elaphe vulpina*).

'Chronic interstitial pneumonia' is reported in one Chicken Snake and a tracheal abscess in a Short-tailed Python (*Python ?*).

The Alimentary System

There is one report of acute haemorrhagic gastritis in a Sand Boa.

Inflammatory conditions of the intestines are referred to in 11 reports, i.e.,

'Enteritis' in a Mole Snake and an Indian Cobra (*Naja naja*).

'Gastro-enteritis' in a Reticulated Python.

'Necrotic enteritis' in a Sand Boa, in a Short-tailed Python affecting the colon and in a Garter Snake (*Thamnophis sirtalis*), coupled with hepatic necrosis.

'Intestinal haemorrhage' in an Indian Cobra and an Egyptian Cobra (*Naja haje*) with congested lungs and liver.

'Inflammation of the large intestine' in a Common Boa

(*Constrictor constrictor*).

'Gangrene of the caecum' in a Common Boa.

'Ulceration of the rectum' in a Mole Snake.

Mechanical injury to the intestine was suspected in a Puff Adder (*Bitis arietans*) and impactions in a Python and an Indian Cobra.

In four reports liver lesions are the principal finding. Hepatic abscesses are reported in a Diamond Back Rattlesnake (*Crotalus atrox*), a Chicken Snake and multiple ones in a Water Snake. Hepatic necrosis is referred to in a Whip Snake.

The Urinary System

One report only included: of a Reticulated Python with 'kidney deposits' and pneumonia.

Other Tissues

An abscess of the head region is reported in a Black Cobra (*Naja ?*).

Subcutaneous abscesses are reported in a King Snake (*Lampropeltis getulus*) and cutaneous lesions probably due to burning in a Black Cobra. (Note similar report on Reticulated Python with verminous infestation of lungs).

Multiple streptococcal abscesses are reported in a Yellow Cobra (*Naja nives*).

Dietary Factors

Doubtless the number included should be much larger but only five reports mention findings which permit them to be classified here.

'Inanition' in a Garter Snake and a Gaboon Viper (*Bitis gabonica*).

Suspected dietary factors in a Grass Snake (*Natrix natrix*).

'Debilitation' in a Black Mamba (*Dendroaspis ?*) and a

Smyth's Snake (*Grayia smythii*).

Parasitic Disease

Five of the seven reports are of parasitic infestation of the lungs or 'airsacs', two Chicken Snakes, a Reticulated Python, a Short-tailed Python and an unnamed Python. In the first of these it was due to 'roundworms' and associated with 'roundworm' infestation of the alimentary tract. In the Reticulated Python, skin lesions suspectedly due to burning are reported.

Impaction of the stomach with roundworms is reported in one Reticulated Python and parasitic gastro-enteritis in another.

Mention of parasitic infestation was also made in reports on a Gaboon Viper, a Black Mamba and a Smyth's Snake.

Special Diseases

Necrosis of liver, kidney and spleen in a Mole Snake. There is no indication as to the origin of this condition.

Violence

The five reports include an Indian Cobra with injuries due to a bite, an Egyptian Cobra with a septic condition of the mouth apparently due to an attempt to remove the fangs, a Reticulated Python with septic pericarditis of traumatic origin, a Cobra with rupture of the liver suspected due to trauma and a Yellow Cobra.

Inconclusive, Etc.

The bodies of a Garter Snake, a Bull Snake, a Black Python (*Python molurus*), two Glass Snakes, a Short-tailed Python and a Russels Viper (*Vipera russelii*) were decomposed when received.

The reports on five Puff Adders, two Mole Snakes,

an Adder, a Gaboon Viper, a Short-tailed Python, a Boomslang (*Dispholidus typhus*), a Sand Boa, a Grass Snake, an Annulated Snake and a Diamond-backed Rattlesnake, were inconclusive.

Period 1950-51

The Alimentary System

OB51/49, an old female Seba's Python (*Python sebae*) had not eaten for three months and the principal findings were congestion of oesophagus, ulceration of stomach and necrotic enteritis affecting the duodenum. An unusual tapeworm with a dumbbell-shaped head was found in the intestine with several large roundworms. Histological examination showed many eosinophils in the necrotic mucosa and in the liver. Bacteriological examination isolated *Proteus* sp. and Coliform organisms from the oesophagus. It is possible that the enteric inflammation was associated with the prolonged abstension from food.

OB51/21, a Water Snake, showed multiple minute abscesses of bacterial origin in intestine and liver tissue. Only *Proteus* sp. were isolated on bacteriological examination.

The Urinary System

OB51/66, a Tessellated Snake, showed little on macroscopic examination, but histological examination revealed almost complete loss of structure of the kidney elements, all forming an a-cellular granular mass infiltrated by eosinophils and roundcells.

The Reproductive System

CB51/57, a Dark Green Snake (*Coluber jugularis*), showed emaciation and a few firm masses of egg yolk material in the oviduct. On histological examination a few scattered parasites were seen in the lung tissue.

CB51/47, another Dark Green Snake, contained within the body cavity a long 'string' of eggs, only two of which appeared normal, the remainder being mere cylinders of inspissated yolk material. The oviduct appeared intensely congested. *Proteus* sp. were isolated from the oviduct.

CB50/66, a Greenleaf Snake, was in thin condition and contained many eggs. No other abnormalities were seen.

Other Tissues

The reptiles included here all died showing purulent abscesses involving either the subcutaneous tissues, including usually the 'thoracic' or 'abdominal' ribs beneath, or lying partly or wholly within the body cavity alongside the gut. Their origin is obscure, but presumably is some traumatic injury to the skin or alimentary canal. Treatment has been unsuccessful when attempted.

CB50/6, a Gaboon Viper: Abscess subcutaneous, about the size of an orange, involving ribs and containing liquid yellow pus. Inspissated ova were seen in the region of the ovaries and roundworms in the alimentary canal. *Proteus vulgaris* and non-haemolytic staphylococci were isolated from the pus.

CB51/59. African Sharp-snouted Snake (*Rhamphiophis oxyrynchus*). Showed two subcutaneous abscesses and one small one in the oesophageal region. All contained green creamy pus. Degenerative changes were seen on histological examination in liver and kidney. *Proteus* sp. were isolated from the pus.

CB51/29. Seba's Python. Large abscess containing thick pus enclosed in a firm capsule adjacent to stomach wall. *Alcaligenes* species were isolated from the pus. Histological examination of viscera showed nothing of significance.

CB50/17. Water Snake. Two subcutaneous abscesses containing

blood-stained semi-solid pus resembling sawdust in appearance. The liver was friable and the oviduct contained eight large eggs. Paracolon organisms were obtained in pure culture from the abscess material.

CB50/13. A Seba's Python, had refused all food, become stuck in a cast and had been treated with thyroid extract and force fed. On post-mortem examination an encapsulated fusiform abscess 12 inches long and an inch and half wide at the centre was found in the region of the heart. It contained creamy pus from which coliform organisms and *Serratia* sp. were isolated.

CB50/12. As in CB50/17 this Water Snake showed a subcutaneous abscess containing semi-solid pus. The viscera appeared normal.

Dietary Factors

All the following snakes were examined post-mortem and no major abnormalities were found. All were known to be receiving inadequate or improper diet, or in the case of the Cobras to have been prevented from feeding by their companions. Most were in an emaciated condition. In one Black-necked Cobra (*Naja nigricollis*) histological examination was carried out and advanced fatty change found in the liver, which showed infiltration with eosinophils as did both the lung and kidney tissue. These changes were ascribed to cachexia.

The Snakes included here are:-

Black-necked Cobras CB51/73, CB51/55 and Grass Snakes CB50/21 and 24.

Baby Puff Adders CB51/17 and 65. (The first of these references includes several of these small reptiles. The number was not exactly known as even when hatched they were too venomous to count and when they died some consumed others, some

dried up and some were received for examination).

Greenleaf Snake CB50/60, Adder (*Viperaberus*) CB51/56, Water Snake CB50/42, Kirtland's Tree Snake (*Thelotornis kirtlandii*) CB50/22, Viperine Snake (*Natrix viperina*) CB50/52, Water Snake CB51/24.

Parasitic Disease

In two Grass Snakes, CB51/51 and CB51/54, the principal abnormality was in the lungs. Histological examination of the tissue showed parasitic infestation with small nematodes to be present. In the former there was some cellular reaction with eosinophils, etc., but in the latter the majority of the parasites lay within a clear space.

An African Lined Snake (*Boadon lineatum*), CB51/64, gave a similar naked-eye appearance to the Grass Snakes. Unfortunately histological examination was not carried out, but although a bacteriological examination isolated *Proteus* species from the lung, verminous infection was strongly suspected and so the case is included here.

CB50/49, another African Lined Snake, showed multiple white lesions in the kidneys which on histological examination were reported as trematodes within the nephrons.

Violence

A Black-necked Cobra CB50/46 and an African Lined Snake CB50/43 died showing severe injuries to the vertebrae and surrounding tissues, presumably caused by the forked stick used in capturing these reptiles.

A Night Adder CB51/37 was killed by Tree Snakes.

Inconclusive, etc.

Grass Snakes CB50/36 and 23 were preserved as specimens. Two others CB51/26 and 60 showed no conclusive finding

as did a Viperine Snake CB51/27, an African Lined Snake CB50/37, a Black and White Cobra (*Naja melaneleuca*) CB51/63, a Smooth Snake (*Coronella austriaca*) CB51/71, and a Greenleaf Snake CB50/61. Most of these were much decomposed.

Two Dark Green Snakes CB51/39 and 41, two Grass Snakes CB50/25 and 31, a Water Snake CB50/27, a Viperine Snake CB50/32, a Cat Snake (*Tarbophis fallax*) CB50/35, a Beauty Snake (*Psammophis sibilans*) CB50/41 and a Tesselated Snake CB51/42, were not submitted for examination.

The cause of death in many of these snakes was probably incorrect feeding.

CLINICAL NOTES - THE REPTILES

Clinical work in reptiles has been even more limited than in birds. Symptoms of disease are, of course, very difficult to recognise in creatures which may, quite normally, remain semi-comatose for days and take food only once in several weeks. A number of superficial abscesses have been incised and evacuated in snakes and lizards, but healing is slow, recurrence frequent and the prognosis never very good. Best results have been obtained with treatment using a Sulphamezathine and Penicillin powder dressing (I.C.I.).

The origin of 'canker' of the mouth in reptiles has been disputed for many years, although it has been claimed that a definite causal organism has been isolated from the pyorrhoec-like condition. Syringing with hydrogen peroxide solution at five volume strength has undoubtedly checked the progress of a similar condition in one large Two-banded Monitor at Edinburgh.

When non-poisonous snakes become "stuck-in-the-cast", manual removal of the still-attached dead skin is employed, but the cause is often a deep seated abscess or other disease condition and any improvement resulting is only temporary. Force feeding by stomach tube is sometimes employed in snakes which refuse food and on one occasion thyroid extract was included in this to attempt to stimulate the snake's metabolism. Casting was completed soon after, but the python died and on post-mortem examination a large encapsulated abscess was found in the body cavity.

The senior reptile keeper has evolved methods of handling his reptiles safely and without injury to themselves or the staff, and except in the case of poisonous ones, no difficulty has been found in examining and medicating them.

A simple chloroform chamber is used for destruction when necessary, and almost any degree of anaesthesia can be induced by lowering the temperature of the reptile's environment. This has not, however, been employed except preceding destruction for fear of the danger of permanent injury. On one occasion a young Monitor about three feet long, which arrived by air during the winter months, was placed on the writer's post-mortem table as "dead-on-arrival." After fifteen to twenty minutes in the warmer atmosphere it completely recovered normal activity, although it had previously shown no evidence of life whatsoever. The use of chloroform as an anaesthetic would appear to be of doubtful value from the one occasion on which it was employed (see Crocodilia 1950-51).

No anthelmintics have been used. Entire tapeworms and roundworms are frequently found in the pools of the pythons' cages and it appears that this self elimination may suffice to prevent the infestation becoming heavy enough to harm the host. Small free moving ticks are occasionally found on newly arrived snakes and large embedded ones on tortoises. These are removed with forceps after the application of crude paraffin.

DISCUSSION - THE REPTILES

As with the birds, a large number of the post-mortem examinations during both periods have been inconclusive and this affects the reliability of all the other figures. In addition, this may account for some of the differences shown in Table F, which compares the figures for Edinburgh with those of Hamerton (1939) for London. Another reason may be that the present writer having been responsible for over half the examinations, the alimentary tract has been 'favoured' as a primary site of disease. An insufficient number of reptiles has been studied to allow statistical comparison of the orders.

The Cardiovascular System

The infrequency of affections of this system is presumably connected with the low metabolic rate of reptiles and the inactive life led by them.

Rewell (1948c) describes arteriosclerosis as rare in reptiles though seen occasionally in Crocodiles and large Lizards.

The Respiratory System

The small number of cases of respiratory affections is surprising when compared to that at London (Table F), and is not easily explicable. Possibly there is some difference in the method of heating the cages in the two Reptiliaries.

The Alimentary Tract

The cases of disease of this system are more or less evenly divided between the four orders and are notable for the frequency of gangrenous or necrotic enteritis and the formation of diphtheritic membranes. Unfortunately examination for

protozoa was not apparently carried out in the first period and only sporadically during the second period, but it seems probable that these parasites may have been the cause of some cases at least.

Protozoal enteritis in reptiles is discussed in papers by Pantham and Porter (1950) and by Ratcliffe and Gieman (1938) in the London and Philadelphia collections. The lesions described in these papers are similar, involving principally the large intestine and also the liver, stomach and occasionally the small intestine. They resemble the lesions seen and reported in several of the cases at Edinburgh, and it is possible that some of the hepatic lesions were also of the same origin.

Osman Hill (1951) discusses the occurrence of 'membranaceous enteritis' in reptiles of the London collection back to 1926 and indicates the similarity of this condition to the outbreak of protozoal enteritis during 1950. He also refers to reports of the disease at Antwerp as well as Philadelphia, the morbid anatomy of the condition being identical with that seen at London.

Rewell (1948a) refers to the occurrence of advanced fatty change in reptilian livers due to no obvious cause.

Hamerton's figure for alimentary disease in the London collection (Table F) is much lower than the writer's. This difference is not easily explained.

So-called "Canker of the Mouth" appears to occur in most zoological collections. Many factors have been suggested for causing this condition, which results in a caseous deposit between the teeth and a necrotising process of the gum and jaw. Rewell (1948a) suggests that either minor injuries or dietary factors are more likely causes than any bacterial agent. He considers it limited to snakes.

The Urinary System

The relatively high percentage of reptilian deaths classified under this heading is due largely to the series of cases in Tortoises during period 1950-51. The condition of bladder distension and rupture which has already been discussed above, is not fully understood and requires better acquaintance with the normal. It is possible that bladder distension is not pathological at all, the organ merely storing liquid for absorption during hibernation, or, as in the case of the turtle, to be used to moisten the sand before egg laying. In captivity Tortoises occupy an environment which has little diurnal and annual temperature variation and this may well cause metabolic ~~watex~~ disturbances. Bladder rupture might possibly occur if water storage was continued and hibernation delayed.

The occurrence of 'arthritis gout' in Tortoises and Lizards may be connected with some similar interference with normal function. As stated before, post-mortem decomposition in reptiles, especially Tortoises, is so rapid that only occasionally are the kidneys suitable for examination. A few times, however, dilation of secretory tubules, increase in interstitial fibrous tissue, and 'sunflower' bodies have been seen. This resembles the description of a late stage of pyelonephritis in the domestic fowl given by Spector (1951). Those kidneys fit for examination sometimes have a 'waxy' appearance and appear to show urate depositis, but these have not been seen histologically, doubtless due to solution in the fixatives or preservative. That the 'sunflower' bodies should have been seen in reptiles and not in birds is somewhat surprising. (see also Discussion concerning birds and Appendix concerning 1952).

It seems likely that dietary imbalance of some kind

is concerned in many of these cases.

Again the difference between the writer's figure and Hamerton's figure for London (Table F) is large.

Mention of kidney disease in reptiles in the reports of other societies is infrequent, but Hamerton (1943) describes urate calculi in a Python.

The Reproductive System

The majority of cases classified here, as explained previously, are Lizards, especially Chamaeleons, which showed no abnormality other than emaciation and appeared to be close to the time of egg-laying. The fact that a similar picture is described by Rewell (1948a) and that only on rare occasions have Lizards been found to lay in captivity at Edinburgh, led to the conclusion that the strain of egg production was a definite factor in causing death. It may be that dietary deficiency or insufficiency is the cause, that a male was lacking and that infertile eggs are not readily laid, or some other factor may be responsible. In several cases in snakes and lizards, malformations of the egg were seen not dissimilar to those occurring in poultry. This has been reported at London by Hamerton (1939, 1941).

Other Tissues

The majority of the cases included here are of abscess formation in snakes. As stated above the origin of these abscesses is obscure. Rewell (1948e) found small nematodes in the abscess wall on several occasions, and the writer has seen similar small coiled nematodes in the subcutaneous tissue of a Cobra, but with no evidence of any suppurative reaction. Sometimes snakes strike at each other at feeding time when kept

captive in groups and it is possible that such bites could lead to abscess formation.

Dietary Disease

No cases of deficiency affecting the skeleton have been encountered during either period. The metabolic requirements for the reptiles no doubt differ from the other classes, but the fact that most reptiles are fed on whole animals would ensure that calcium and phosphorus in the right proportions are in good supply.

The fact that captive snakes are reluctant at first to feed on dead prey and the difficulty of providing a constant supply of flies (which has recently been overcome by obtaining a regular supply of blowfly larvae) accounts for the high mortality from dietary disease in general. Hamerton's figure for London (Table F) is comparably high.

Parasitic Disease

The level of parasitic disease as a principal finding has not been high in the reptiles, although parasites, especially large 'roundworms' and cestodes, have been found quite frequently in reptiles dying from other causes and in the excrement of living reptiles. The question of alimentary protozoa has been discussed already. Blood parasites have not been searched for, but Rewell (1948e) describes the haemogregarines of reptiles as common and of little significance.

Fox (1936) states that "It is very probable that many of the nematode parasites of reptiles and amphibia have a direct cycle so that infection could have been built up in the gardens."

Reference has already been made to Linguatulid infestation of the lungs in snakes, in the Mammalian discussion

above. Fantham and Porter describe pulmonary infestation with species of the Forocephalidae in several South African snakes. They give a detailed discussion of many endoparasites.

Neoplasia

Neoplasia appears to be very rare in reptiles. Few reports of it occur in the reports of London or Philadelphia. Rewell (1950) describes papillomatosis of the skin in Lizards similar to that seen in the Bearded Lizards here. He states that it appears to occur in various centres in England and Germany and may possibly be infectious. Ratcliffe (1936) describes carcinoma of the pancreas of a Say's Pine Snake, the first tumour in 380 reptiles examined. In a later paper (1943) he finds that a form of neoplastic disease of unexplained origin is of fairly frequent occurrence in the pancreas of snakes.

Tuberculosis

Reptilian tuberculosis has been uncommon at Edinburgh and does not appear to be very frequent in other collections. It is reported at London by Osman Hill (1951) and Hamerton (1943 and 1939). Fox (1930), describing six cases in snakes and one in a Teguixin refers to the organism as "Mycobacterium thamnophis."

Special Diseases

The infrequency of infectious disease among reptiles is not surprising in view of their sluggish habits. Only one case has been included, a Mole Snake, where the affection of several organs appeared to indicate a generalised infection.

Hamerton (1939) reports mycotic lesions in a Python and a Terrapin.

Violence

sometimes
 Death/occurs in reptiles from injuries received months previously, probably caused by the forked stick used in capturing them. The low metabolic rate presumably causes the necrotising processes to assume a very chronic form. Some fighting occurs among Lizards with fatal results, and the crushing of a female Monitor is described presumably due to the mating attentions of an overlarge male.

In general, however, death from fighting injuries is not common in the reptiles at Edinburgh.

Inconclusive, etc.

Post-mortem decomposition is one of the principal reasons for the large percentage of cases included here.

"New Arrivals" and "Old Stock"

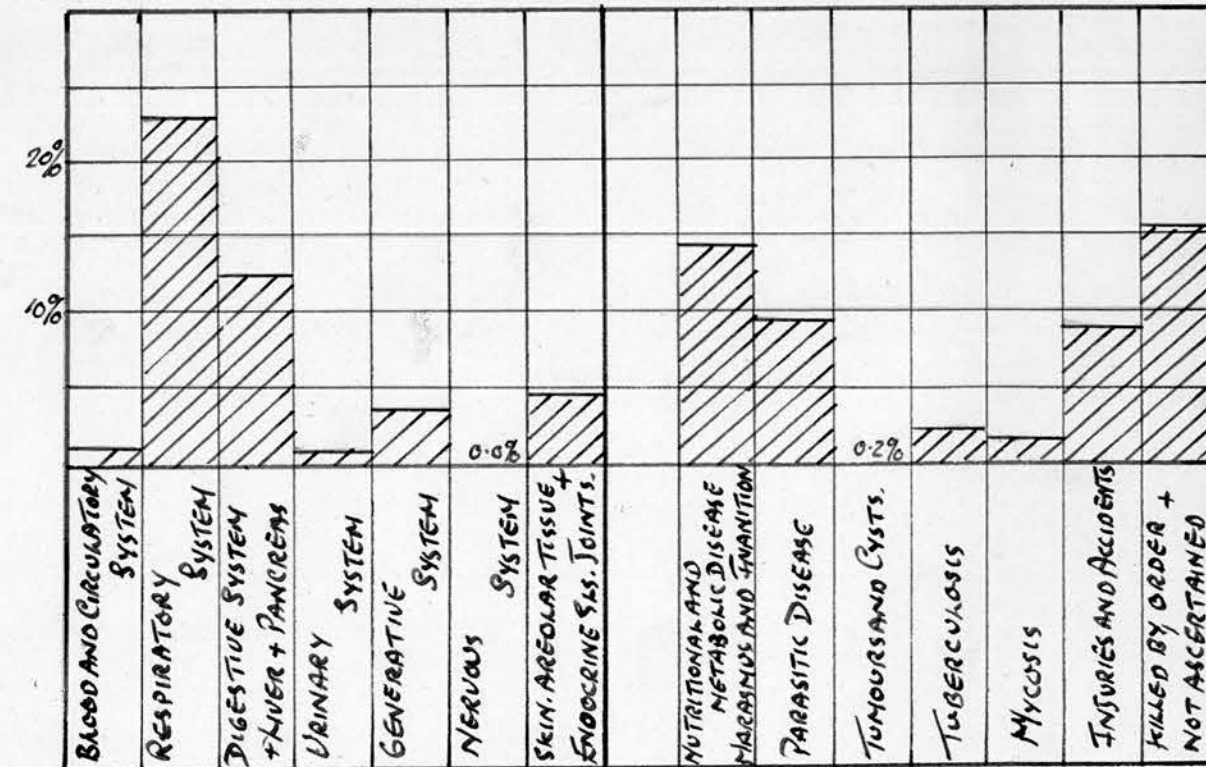
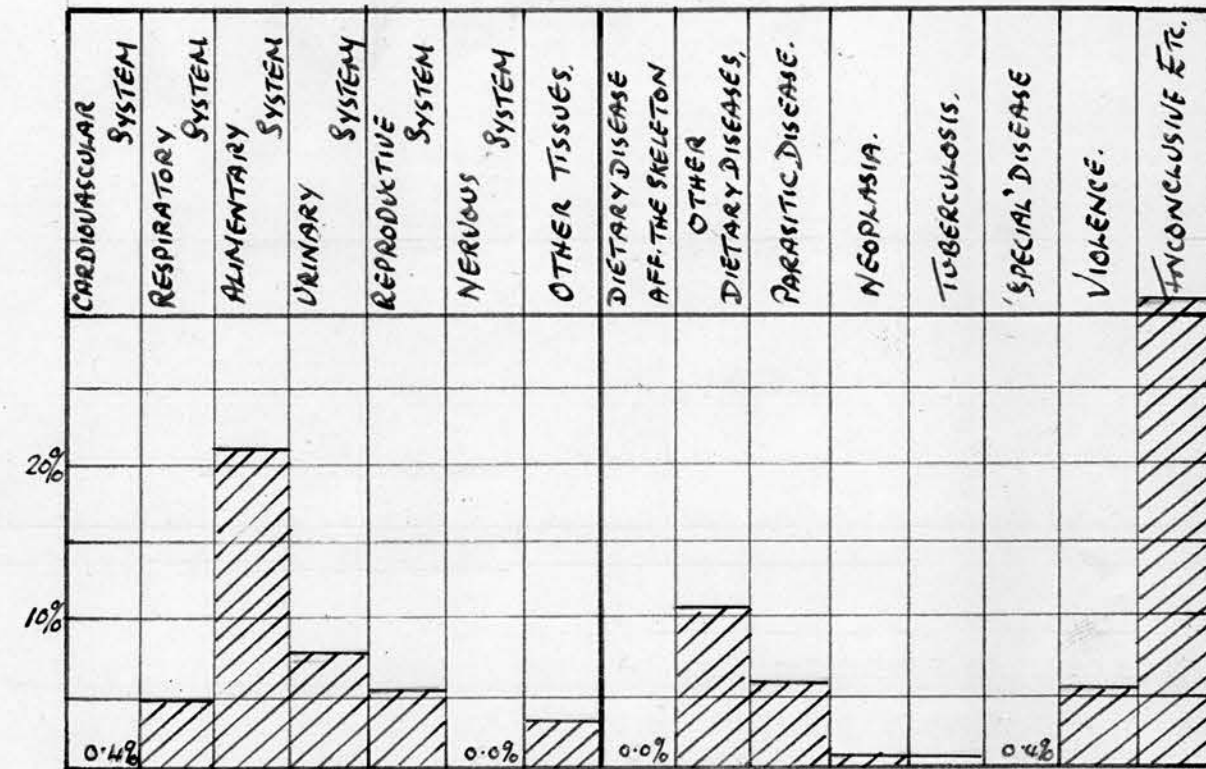
Table F shows that the majority of deaths among reptiles in period 1950-51 have occurred in "New Arrivals", i.e., reptiles present in the park less than six months. This is mainly due to deaths in the Testudinata, particularly Tortoises, and the Sauria, especially Chameleons and Agama Lizards. The reasons have already been discussed.

TABLE F.ANALYSIS OF DEATHS IN THE REPTILIAN ORDERSCOMPARISON WITH LONDON.

REPTILIA.

ORDER.	TESTUDINATA.			LORICATA.			SAURIA.			SERPENTES.			TOTAL	PERCENTAGE
PERIOD.	P ₁	P ₂		P ₁	P ₂		P ₁	P ₂		P ₁	P ₂			
		N.A.	O.S.		N.A.	O.S.		N.A.	O.S.		N.A.	O.S.		
CARDIOVASCULAR SYSTEM	.	.	.	.	.	.	1	.	.	.	.	.	1	0.4
RESPIRATORY SYSTEM	.	.	.	1	.	.	2	.	.	10	.	.	13	5.0
ALIMENTARY SYSTEM	3	5	4	8	.	1	8	2	4	19	.	2	56	21.6
URINARY SYSTEM	.	9	4	.	.	.	1	1	3	1	.	1	20	7.7
REPRODUCTIVE SYSTEM.	.	.	.	.	.	.	1	10	1	.	.	3	15	5.8
NERVOUS SYSTEM.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
OTHER TISSUES.	.	.	.	.	.	.	.	.	.	4	.	6	10	3.8
DIETARY DISEASE AFF. THE SKELETON	.	.	.	.	.	.	.	.	.	.	.	.	.	.
OTHER DIETARY DISEASE.	1	.	.	.	.	.	.	8	1	5	6	6	27	10.4
PARASITIC DISEASE	1	.	.	.	.	.	3	.	1	7	2	2	16	6.2
NEOPLASIA.	.	.	.	.	.	.	.	2	.	.	.	.	2	0.8
TUBERCULOSIS.	.	.	.	2	.	.	.	.	.	.	.	.	2	0.8
'SPECIAL' DISEASE	.	.	.	.	.	.	.	.	.	1	.	.	1	0.4
VIOLENCE	.	.	.	4	1	.	.	2	.	5	2	1	15	5.8
INCONCLUSIVE ETC	8	5	3	5	.	.	5	9	6	22	8	10	81	31.3
TOTAL	13	19	11	20	1	1	21	34	16	74	18	31	259	100%
TOTAL	13	30		20	2		21	50		74	49		259	
TOTAL.	43			22			41			123			259	

EDINBURGH.



LONDON.

Table Drawn from the figures of Hamerton (1939)

CLASS AMPHIBIA

The majority of amphibians which die, i.e. the small African Tree Frogs, a large number of which are kept, are not received for post-mortem examination as they shrivel up or decompose in dark crannies among the racks in their cage. No reports exist for the period 1938-49, indicating that none were submitted for examination, not that none died.

The amphibians are kept in glass-fronted, heated cages in the Reptile House, and are fed on small cockroaches, blue-bottles and *Drosophila* both winged and wingless, bred for the purpose.

Period 1950-51

These cases are of little significance, but are included for the sake of completeness.

CB50/40. Toad (*Bufo bufo*) Decomposed.

{ CB50/68 and 69. Marbled Tree Frogs (*Hyperolius marmoratus*)
{ CB51/25 and 28. Malayan Tree Frogs (*Rhacophorus leucomystax*)
{ Preserved as specimens.

CB51/2, CB50/59 Tree Frogs

{ CB51/20 Marbled Tree Frog)
{ CB51/6 and 7. Tree Frogs) Not examined.
{ CB51/36 Swan River Toad (*Pseudophryne australis*)

CB51/48. African Bull Frog (*Rana occipitalis*) showed deposit of sand in intestine, probably due to perverted appetite from dietary cause.

CB51/80. African Bull Frog. Intestine obstructed by pebble at pelvic inlet.

CB51/68. African Bull Frog. Stomach full of fibrous material and intestine contained sand. Melanosis of liver.

CB51/79. African Bull Frog. Numerous worms in lung. Haemorrhagic and cellular exudate seen in air spaces on

histological examination. Kidney tissue intensely infiltrated with monocytes and polynuclear cells.

CB51/62. African Bull Frog. Little abnormality seen except for melanosis of the liver in which one small 'actinomycosis-like' granule was seen microscopically.

CB51/69 and 70. Two African Bull Frogs. The first was decomposed and the alimentary tract seen to be empty. The second showed slight subcutaneous bruising and sand in the intestine. Histological examination revealed hepatic melanosis.

CB51/68, 69, 70. All died shortly after Geckos were placed in the same cage and it may be that these prevented them feeding or disturbed them in some other way.

Some sections were stained by the writer with Claudius's stain and examined for Monilial infection as referred to by Scott (1926) and Osman Hill (1951) but no evidence of this was found.

MORTALITY IN RELATION TO POPULATION

Before December 31st, 1949, no record exists of the number of stock kept in the park at any one time, and therefore no mortality rate can be worked out for the years preceding 1950. This means that no really reliable estimate of mortality rate can be made for several years to come as it is necessary to compare the figures for about a decade. None the less inventories of the stock have been made by the writer on December 31st, 1949, 1950 and 1951. Table V gives the figures for all stock except Amphibia, Pisces and Invertebrata kept, the number of deaths including new born young and the mortality rates for the two years. The percentage given is the mortality figure compared to the mean stock figure (i.e., the sum of the figures for December 31st at each end of year, divided by two). It is realised that this mean stock figure can give rise to inaccuracies because of animals arriving and dying in the same year, and so on, but it forms the best working basis.

Table V gives the stock and mortality figures for the individual orders of all three classes. The figures are too small for any estimation of the relative "tolerance of captivity" of the various orders, but they do show that, although the total mortality figures for the classes ⁱⁿ the two years are not dissimilar, the figures for the various orders, particularly birds, differ considerably. Among the mammalian orders Rodentia appears to stand out from the others but the apparently high mortality rate is in part due to the death of several litters of young Crested Porcupines. It is to be expected, however, that the relatively shorter, natural life span of ~~these~~ many small Rodents would tend to increase the mortality rate among them.

The large number of deaths among the Passeriformes in 1950 was due to the arrival of a large consignment of tropical finches in rather poor condition due to overcrowding en route, and the death of the majority of them during the succeeding months. The other order which stands out among the birds is the Sphenisciformes. No new consignment of Penguins came during 1950, the stock figure representing old established birds and the mortalities being few. In 1951, however, a group of Ringed Penguins in poor condition arrived and the high mortality figure for the year 1951 illustrates the deaths among the new birds from mycosis.

To some extent variations in mortality among the orders from year to year cancel one another out. As stated above, a true picture of the mortality rate cannot be gained from the study of only two years' figures, but they give an indication of that picture and it has been thought worthwhile to compare them with those of the other zoological gardens where published figures are available.

The four chosen - London, Philadelphia, New York and Vincennes - publish an annual report which includes stock and mortality figures. For the first three figures have been obtained for many years back, but for the last, only the reports for two years. Vincennes' annual report for 1951 has not as yet been received.

The statistics given in the reports of the other societies differ slightly from one another and from the writer's. London's mortality percentage is evidently calculated in the same way as that used in the figures for Edinburgh, but no mention is made of the inclusion of new born young in the figures. Philadelphia calculate their percentages on a basis of

mortality compared to "Stock Exhibited," but mention that certain animals and birds which have been exhibited but are not "in the collection," are not included in the mortality list. New York gives its mortality rate as a percentage of the Total Collection, i.e., the sum of the stock on December 31st of the preceding year plus all those arriving during the year, departures not being deducted. Mortalities among new born and new arrivals are included. Vincennes publishes only the stock figures for December 31st and a mortality list divided into 'Adults acclimates,' 'Animaux récemment importes,' and 'Jeunes.' The mortalities of these three categories have been added together in the table given and the 'mortality rate' calculated in the same way as for Edinburgh. Neither Philadelphia, New York or Vincennes give figures for reptiles and none of the four make any attempt to assess mortality rate at an 'order' level.

From Table VII it can be seen that, taking the two years together, there is little real significant difference at Edinburgh between the mortality rate of mammals and birds, but there is a significant difference between these classes and the reptiles.

Comparison

Table VII compares the mortality rates for the several collections using the summated figures of the two most recent years for which figures are available, i.e., 1950 and 1951 in Edinburgh, London, Philadelphia and New York, and 1949 and 1950 in Vincennes. In Table VI the figures for all the post-war years are given as a matter of interest and to show the variability of mortality rates, but except for the years mentioned here they are not used for comparison.

Comparing Edinburgh with London it can be seen that there is no significant difference in the mortality rate of the three classes, although, like Edinburgh, there is a significantly higher death rate at London in the reptiles as compared to the birds and mammals.

Comparing Edinburgh with Vincennes, the difference in the mammals' mortality rate is not significant (at a 99 per cent level of chance variation) although the difference in the birds' mortality rate definitely is.

Comparing Edinburgh with New York and Philadelphia, there is a highly significant difference between both the mammalian and the avian mortality rates.

Discussion

It is realised, as stated above, that an analysis covering only two years is far from accurate, and that even employing a 99 per cent level of chance variation, no definite pronouncements can be made upon the final figures. None the less the figures indicate certain probabilities which are worth setting down, as they are the only way available of comparing the overall mortality picture at Edinburgh with that of other zoological collections.

1. That the death rate among reptiles in captivity at Edinburgh is higher than the death rate in birds and mammals. This also applies to London, the only other collection from which published figures are available.

2. That the mortality rate for all three classes at Edinburgh is very similar to that shown by London's figures which are presumed to include new born young. If, on the other hand, they do not include new born young, then the mortality rate at

Edinburgh may in fact be considerably lower than that at London.

3. That the mortality rate for Mammals and Birds at Edinburgh appears to be considerably higher than that at Vincennes.

Statistically the difference is not significant in the Mammals although it is in the Birds.

4. That there is a highly significant difference in the mortality rate for Mammals and Birds between Edinburgh and both the Philadelphia and New York collections.

These four points are fairly readily explained.

The first is almost certainly due to the differing metabolism of the reptile and the consequent difficulty of providing ideal food, recognising and treating disease and so on.

Some similarity between Edinburgh and London is to be expected as the type of animals kept and the general organisation are similar.

The lower mortality rate at Philadelphia is doubtless connected with the activities of the Penrose Research Institute. This organisation has a staff of pathologists, bacteriologists, nutritionists and parasitologists which has been working upon the problems of disease in captive wild animals since the early years of the century. In addition it is understood that Philadelphia, like most American Zoological Gardens, has an assured income which makes the establishment of optimum housing, diet and other requirements for the stock a much easier matter. Also, their figures are calculated on a basis which would tend to give a slightly lower mortality rate.

The reports of the Vincennes Society contain little information as to the general organisation of the zoological park.

The lower mortality rate at New York is partly explained by their method of estimating it, and, although no laboratory comparable to the 'Penrose' at Philadelphia exists there, the financial position of the Society is probably similar.

To conclude this section it remains only to say that on the basis of the incomplete figures available, the mortality rate at Edinburgh for the classes Mammals, Birds and Reptiles appears to be similar to that of the principal British Zoological Park although higher than that at one of the principal Continental and two of the principal American Parks. In view of its relative youth, the small population/and its climatic difficulties, this would seem to be a considerable achievement.

TABLE V
STOCK AND MORTALITY FIGURES FOR EDINBURGH

	S T O C K			M O R T A L I T Y					
	1949	1950	1951	1950	1951				
Primates	62	69	64	11	13				
Carnivora ¹	75	93	90	18	13				
Rodentia ²	34	47	37	24	29				
Ungulates ³	47	59	63	12	15				
Marsupialia ⁴	20	19	16	3	6				
Passeriformes	35	182	177	102	39				
Piciformes	-	6	8	-	-				
Coccygiformes	6	9	7	2	3				
Coraciiformes	2	3	1	-	2				
Psittaciformes	90	72	140	20	19				
Strigiformes	19	18	14	6	7				
Accipitriformes	34	29	26	5	9				
Pelecaniformes	8	9	14	5	1				
Phoenicopteriformes	4	2	16	2	4				
Anseriformes	79	76	55	16	16				
Ardeiformes	37	33	28	6	9				
Baleariciformes	14	15	10	2	4				
Charadriiformes	1	-	4	-	2				
Lariformes	5	9	4	2	3				
Alciiformes	1	1	1	3	3				
Spherisciformes	41	50	62	5	31				
Ralliformes	1	2	6	1	1				
Columbiformes	85	49	22	8	6				
Galliformes	50	32	39	12	7				
Rheiformes	2	2	2	-	-				
Struthioniformes	6	4	2	2	2				
Testudinata	26	52	45	13	17				
Loricata	9	4	3	1	1				
Sauria	34	45	34	27	23				
Serpentes	29	29	29	24	25				
	1949	Mean	1950	Mean	1951	1950	%age	1951	%age
TOTAL MAMMALS	238	262	287	278	270	68	25.9	76	27.2
TOTAL BIRDS	520	561	603	620	638	199	35.2	168	27.0
TOTAL REPTILES	98	114	130	118	111	65	52.6	66	55.9

1. Including Pinnipedia.

2. Not including Mice, Rats, Guinea Pigs, Golden Hamsters or Lagomorpha.

3. Including Perissodactyla, Artiodactyla and Proboscidea.

Not including domestic sheep.

4. Including Edentata.

TABLE VI
COMPARISON OF THE MORTALITY RATE IN OTHER ZOOLOGICAL COLLECTIONS

		S T O C K						M O R T A L I T Y									
		1946	1947	1948	1949	1950	1951	1946	%age	1947	%age	1948	%age	1949	%age	1950	%age
LONDON (1)	Mammals	737	816	827	895	839	887	271	42.6	332	42.7	255	31.2	276	32.1	236	28.1
	Birds	1412	1524	1580	1836	1919	1927	348	29.9	433	29.5	331	21.3	366	21.4	553	28.2
	Reptiles	563	747	722	787	740	722	194	40.4	393	60.0	432	58.8	339	44.9	428	57.8
PHILADELPHIA (2)	Mammals	458	660	513	521	526	556	58	12.6	73	11.0	59	11.3	50	9.6	43	8.2
	Birds	858	946	946	947	1029	1016	230	26.8	150	15.8	167	17.6	125	13.2	194	18.8
NEW YORK (3)	Mammals	651	709	660	721	697	691	110	16.9	113	16.0	95	14.4	115	16.0	117	16.8
	Birds	1573	1991	1763	1645	1816	1617	217	13.8	276	13.9	261	14.8	248	15.1	283	15.6
VINCENNES (4)	Mammals	-	-	529	536	582	-	-	-	-	-	-	-	88	14.6	122	21.9
	Birds	-	-	582	619	707	-	-	-	-	-	-	-	100	16.6	90	13.5

Figures are drawn from the Annual Reports of:-

- (1) Hemerton Rewell, Osmer Hill.
- (2) Ratcliffe.
- (3) Goss.
- (4) Urbain et al.

TABLE VII

COMPARISON OF MORTALITY RATE AT EDINBURGH
WITH OTHER COLLECTIONS DURING A SIMILAR PERIOD

	MAMMALS				BIRDS				REPTILES			
	Total Mean Stock Figure 1950 + 1951	Total Deaths 1950 + 1951	Mortality Rate Percentage	Statistical Variation (at 99% level)	Total Mean Stock Figure 1950 + 1951	Total Deaths 1950 + 1951	Mortality Rate Percentage	Statistical Variation (at 99% level)	Total Mean Stock Figure 1950 + 1951	Total Deaths 1950 + 1951	Mortality Rate Percentage	Statistical Variation (at 99% level)
EDINBURGH	540	142	26.6	± 5.7	1181	367	31.0	± 4.0	232	131	56.4	± 9.8
LONDON	1730	486	28.0	± 3.2	3800	1006	26.0	± 2.1	1494	761	50.9	± 3.9
PHILADELPHIA	1064	111	10.4	± 2.8	2010	360	17.0	± 2.5	-	-	-	-
NEW YORK	1403	221	15.6	± 2.9	3446	533	15.4	± 1.8	-	-	-	-
VINCENNES *	1089	210	19.2	± 3.6	1263	190	15.0	± 3.0	-	-	-	-

* The figures for Vincennes concern the years 1949 and 1950, not 1950 and 1951.

FINAL DISCUSSION AND SOME GENERAL CONCLUSIONS

The individual orders and classes of animals have already been discussed, and Table G includes the total figures for the three classes studied. In general a considerable degree of similarity can be seen in the three columns of percentages, although certain differences do exist. Within each class the type of metabolism and anatomical form are to some degree constant, which permits comparison of the orders according to the fifteen headings chosen, but between the classes this does not apply. In addition, the incompleteness of much of the material available for study, the high percentage of inconclusive examinations on Birds and Reptiles, and the relatively small total number of examinations carried out in all, renders a comparison of the classes of little value except in the most general terms.

The Principal Causes of Mortality and Morbidity

From the fourth column and the histograms in Table G it can be seen that excluding the 'Inconclusive' cases, the largest percentages of deaths fall under the heading of the Alimentary System, Violence, the Respiratory System, Special Diseases and Tuberculosis, Dietary Factors, Parasitism and the here considered Urinary System/in that order. Diseases affecting the Cardio-vascular, Reproductive and Nervous Systems, and Neoplasia are of relatively small importance.

The Alimentary System

Affections of this system diagnosed as due to parasitic infestation or dietary disease have been excluded from this category, and in the majority of cases exact etiology of the condition included is not known. Although some parasitic

disease may have been overlooked, it seems probable that unrecognised dietary factors play an important part. Indiscriminate feeding by the visitors is another cause, the effect of which is not easily estimated.

Violence

That this should occupy so high a place in the table is at first sight somewhat surprising. In the mammals, however, many of the deaths are new-born young which are killed by the adults, and this number can only be reduced by the provision of more accommodation - a slow and expensive process. Among the birds much fighting occurs at mating time and is impossible to prevent entirely if birds are to be kept in groups at all. The division of one large Parrot aviary in 1951 has, however, already resulted in some reduction of the number of deaths from this cause. Many of the smaller Passerine birds take fright readily and die from concussion by flying into the walls and this would appear to be unavoidable.

Injuries due to rats have largely ceased since their destruction on a large scale was undertaken in 1950.

Violence is not a very important cause of death in the Reptiles, although different methods of catching them, if such were possible, would prevent deaths occurring at a later date due to injuries received before arrival.

The Respiratory System

Little comment is required here except perhaps to state that the number is rather smaller than might be expected, especially among the Reptiles. In the case of the birds, congestion of the lungs in the Passerine species is the largest group, and it is possible that the frequency of this condition

might be reduced if more provision was made to prevent chilling. The open air type of housing employed for much of the stock has possibly reduced the incidence of bronchopneumonia in the Felidae and of respiratory conditions generally in other stock.

Special Diseases and Tuberculosis

The incidence of Tuberculosis has been very low throughout all the orders with the exception of the Galliformes. The reasons for this have already been discussed.

The Special Disease heading includes a number of conditions. The most surprising feature has been the rarity of tropical diseases and the fact that no epizootics of the common infectious diseases have occurred during the periods reviewed. The figure for mammals is increased by a number of cases of *Pasteurella pseudotuberculosis* infection in the order Lagomorpha, the members of which are not kept strictly under "zoo" conditions. The figure for birds is largely made up of cases of the disease mycosis, principally among Penguins. In view of the value and importance of Edinburgh's collection of these birds, this disease is the single factor causing mortality that would best repay investigation.

Other special diseases of some importance are Nocardiosis in Wallabies and possibly Actinomycosis in Tapirs if the latter animals are to be kept in the collection in the future.

Dietary Factors

In 6.6 per cent of cases dietary disease of one form or another has appeared to be the principal cause of death, but there is little doubt that dietary factors are responsible for many more deaths than this would indicate. The majority of the

diagnosed cases have been due to well recognised deficiencies and insufficiencies largely caused by the difficulties of war-time. No attempt has, however, been made at Edinburgh to study the general nutritional requirements of the stock systematically in the manner in which it has been done at Philadelphia (vide Ratcliffe, 1940). Such an investigation would be of value among all classes of stock.

Dietary disease affecting the skeleton has only been of importance in mammals. Most of these have been affected before arrival, during the second period studied, and as described, the practice of sending mineral and vitamin supplements to intending exporters has been initiated.

Parasitic Disease

This has already been discussed at considerable length. The comparatively high level of parasitism in the Mammals is due principally to the Order Artiodactyla, and is the excluding order Lagomorpha principal/disadvantage of the 'limited pasture' type of husbandry employed at Edinburgh. Increased solid floored accommodation for these animals during the winter months would largely remove the dangers of parasitic disease while retaining the advantages of the 'naturalistic' methods of exhibition during the summer months.

The Urinary System

The abnormalities seen in the urinary tract of Birds and Reptiles are of considerable interest and, while not perhaps of primary importance in the mortality picture as a whole, may well yield interesting results on further study.

Comparison with Other Zoological Collections

Table G includes a histogram drawn from Hamerton's

figures for the London collection during the pre-war period. This shows a considerable similarity to the picture which has been obtained for Edinburgh. The principal differences are the higher level of alimentary disease and parasitic disease and the lower level of violence at Edinburgh. Although the total figure for tuberculosis infection is also higher at Edinburgh than at London, it has already been explained that this is almost entirely due to the one order Galliformes, and that otherwise the disease appears to have been of much less importance than at London.

Comparing Edinburgh with other zoological collections it would appear that there is a degree of similarity in the general disease findings, but that many more differences exist than between Edinburgh and London. This is to be expected in view of differing conditions of climate, management, availability of foodstuffs and so on that obtain in other countries.

The Mortality Rates in the collections for which figures are available have already been compared.

Clinical Treatment

Little can be said concerning this subject except that its importance is small compared to the general measures of hygiene, nutrition and prophylaxis. Some clinical work will always be necessary, however, for even under optimum conditions a degree of animal disease will continue to occur.

The study of animal behaviourism is of great importance in this, as in every other aspect of keeping wild animals in captivity.

The Transport of Animals

During the period which the writer has spent at the Edinburgh Zoological Park, new animals have usually

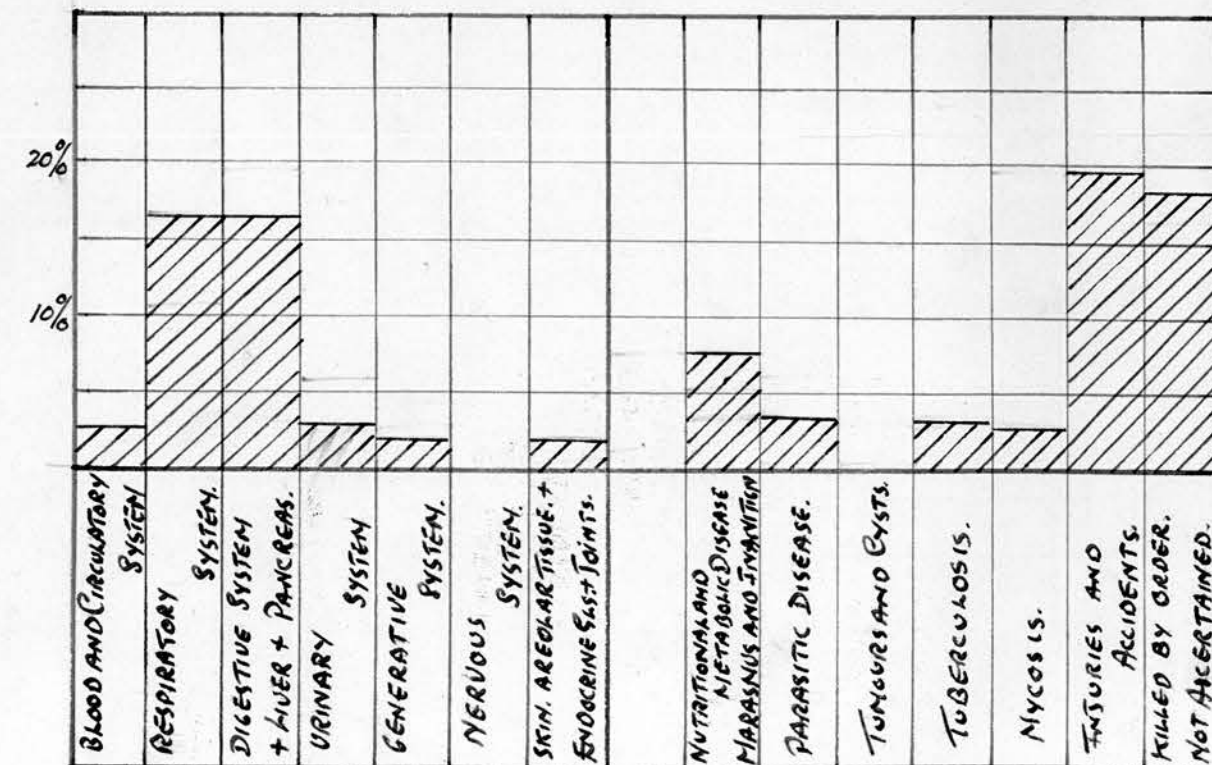
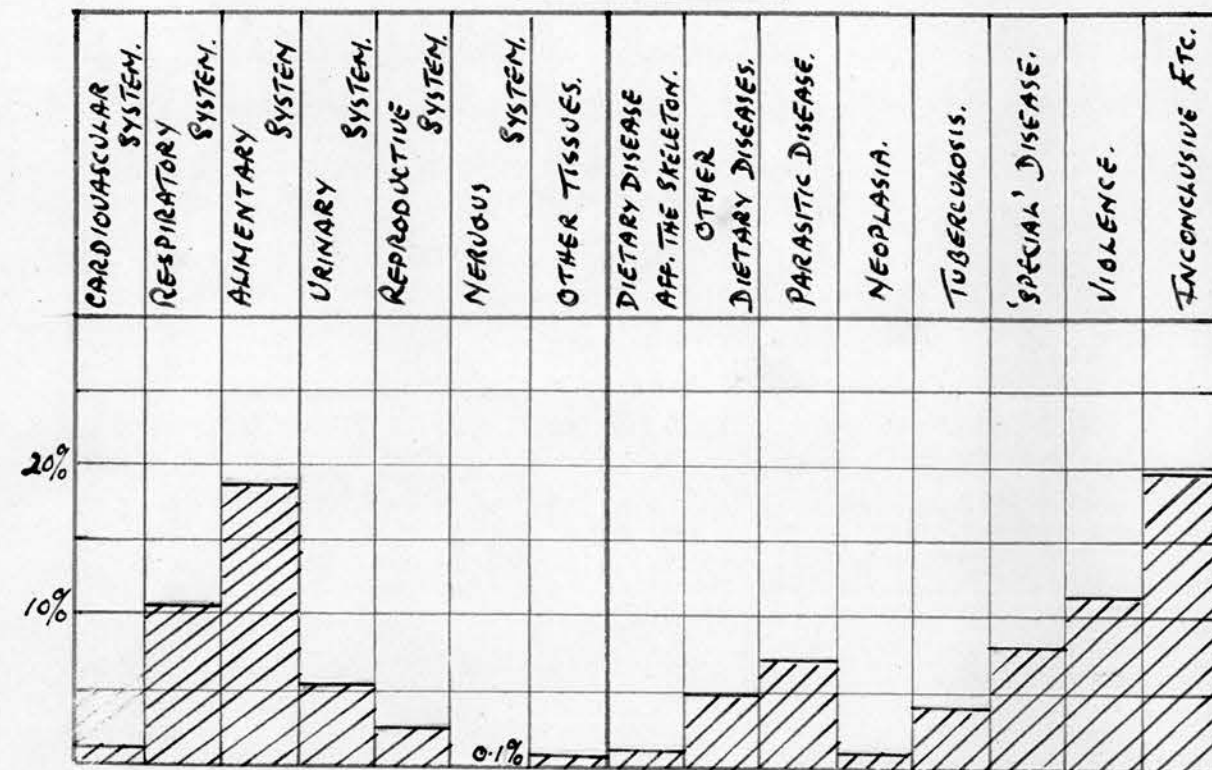
arrived well boxed and in good condition. The exceptions to this have been some birds, mammals showing bone disease, and some badly packed reptiles. It would appear that in general the efforts of those who have striven to improve conditions of animal transport have borne some fruit. There is still room, however, for a better knowledge among some shippers and exporters of the information contained in such excellent advisory articles as that produced by the committee of the London Zoological Society in 1928* and that recently issued by K.L.M. airlines.

* Hints on the Transport of Animals. Proc. Zool. Soc. Lond. 1928. Part II.

TABLE GTOTAL FIGURES FOR THE THREE CLASSESCOMPARISON WITH LONDON.

	MAMMALIA		AVES.		REPTILIA.		TOTAL	
	No	%	No	%	No	%	No	%
CARDIOVASCULAR SYSTEM.	20	2.0	18	1.4	1	0.4	39	1.6
RESPIRATORY SYSTEM.	130	13.2	125	10.1	13	5.0	268	10.8
ALIMENTARY SYSTEM.	224	22.7	187	15.0	56	21.6	467	18.8
URINARY SYSTEM.	33	3.3	91	7.3	20	7.7	144	5.8
REPRODUCTIVE SYSTEM.	14	1.4	41	3.3	15	5.8	70	2.8
NERVOUS SYSTEM.	3	0.3	.	.	.	.	3	0.1
OTHER TISSUES.	11	1.1	7	0.6	10	3.8	28	1.1
DIETARY DISEASE AFF. THE SKELETON	35	3.5	4	0.3	.	.	39	1.6
OTHER DIETARY DISEASE.	60	6.1	37	3.0	27	10.4	124	5.0
PARASITIC DISEASE.	97	9.8	65	5.2	16	6.2	178	7.2
NEOPLASIA.	29	2.9	15	1.2	2	0.8	46	1.8
TUBERCULOSIS.	19	1.9	97	7.8	2	0.8	118	4.7
'SPECIAL' DISEASE.	70	7.1	120	9.7	1	0.4	191	7.7
VIOLENCE.	120	12.2	148	11.9	15	5.8	283	11.4
INCONCLUSIVE ETC.	121	12.3	288	23.2	81	31.3	490	19.7
TOTAL.	986	100%	1243	100%	259	100%	2488	100%

EDINBURGH



LONDON.

Drawn from the figures of Hamerton (1939)

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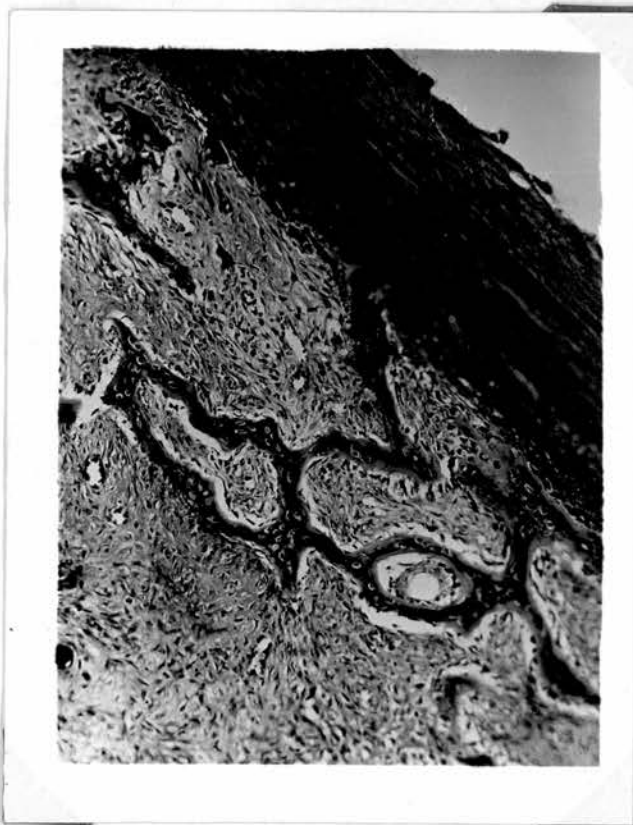
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Osteodystrophia FibrosaP51/11 Brown Woolly Monkey (*Lagothrix infumatus*)

1. Showing distortion of skull and longbones. The skin of the right limbs and head has been reflected.



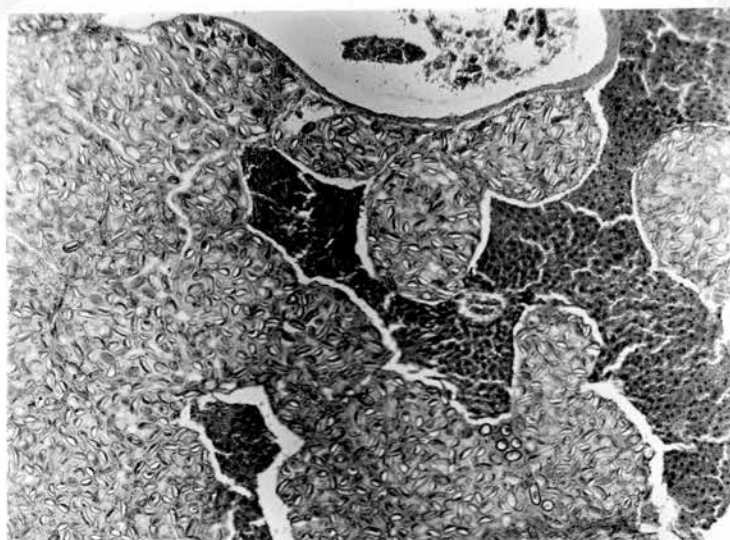
2. Microphotograph of edge of shaft of longbone showing islands of bone surrounded by fibrous tissue. x 130.
Haematoxylin-Eosin.

Hepaticola Hepatica Infestation

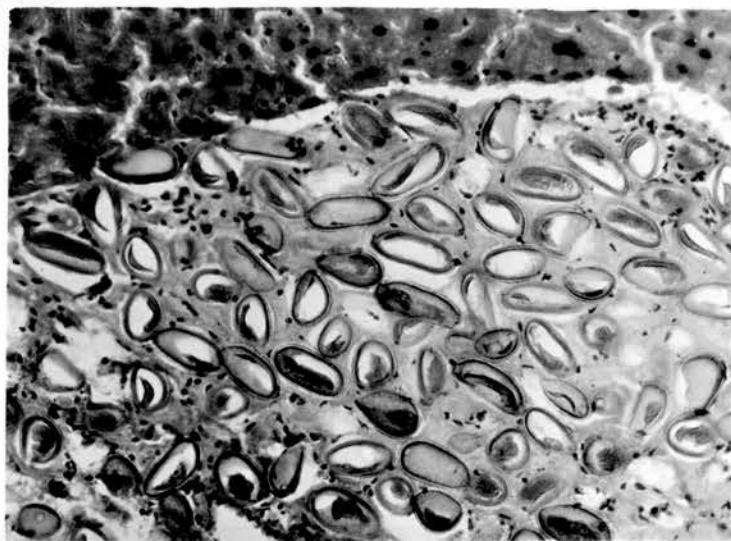
R51/16 Long-tailed African Rat



1. The Liver.



2. Microphotograph of liver tissue showing large areas replaced by nematode eggs.
x 50.
Haematoxylin
- Eosin.



3. Microphotograph of liver tissue showing large numbers of nematode eggs.
x 275.
Haematoxylin
- Eosin.

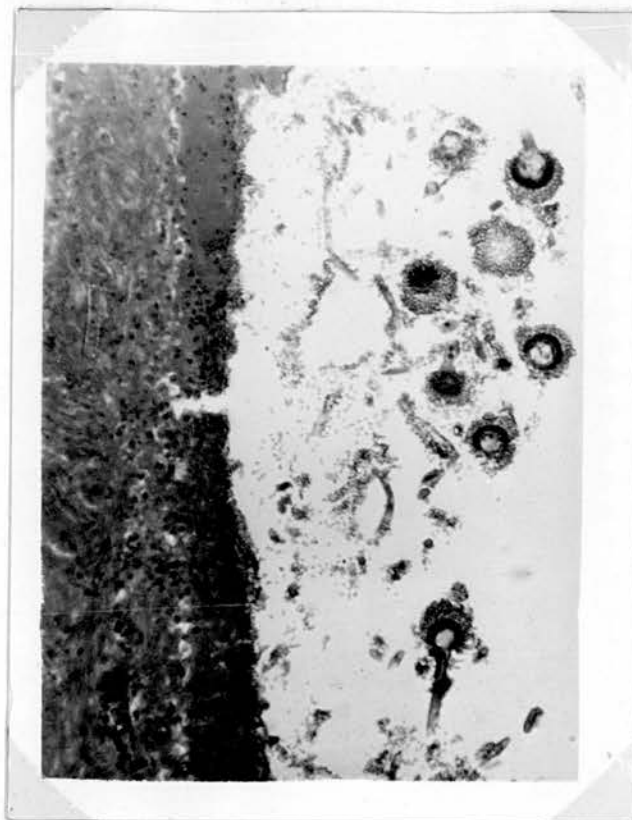
MycosisRinged Penguin (*Pygoscelis antarctica*)

Dissection of the trunk showing:-

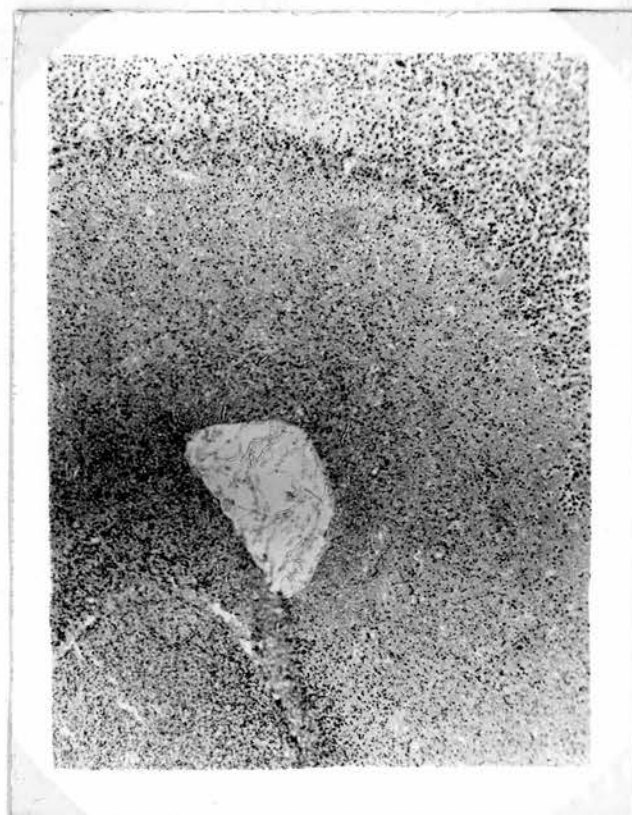
1. Thoracic airsacs thickened with caseous deposit



2. Large colony of mould attached to serous surface of the oesophagus.
3. Right abdominal airsac lined by caseous cast with hollow centre.



A51/49. Ringed Penguin (*Fygoscelis antarctica*)
Microphotograph of lung tissue showing presence of fungal
conidia. x 275. Haematoxylin-Eosin.



A51/60. Ringed Penguin.
Microphotograph showing hyphae growing out into the tertiary
bronchiole from the consolidated area of lung tissue.
x 160. Haematoxylin-Eosin.

Uratic 'Gout'

A51/159. Ring-necked Parrakeet (*Psittacula manillensis*)

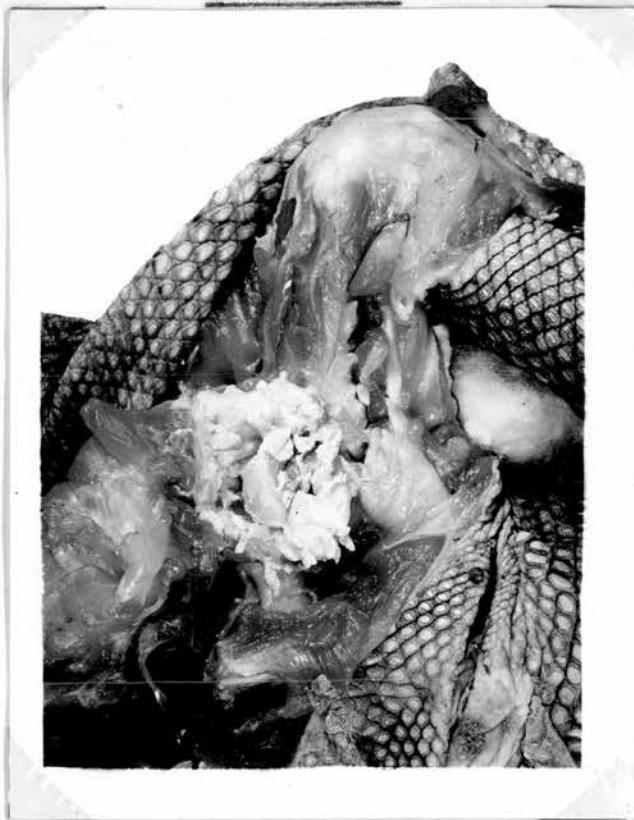


1. Showing distension of the feet with deposits of urate material. Skin removed from part of right foot.



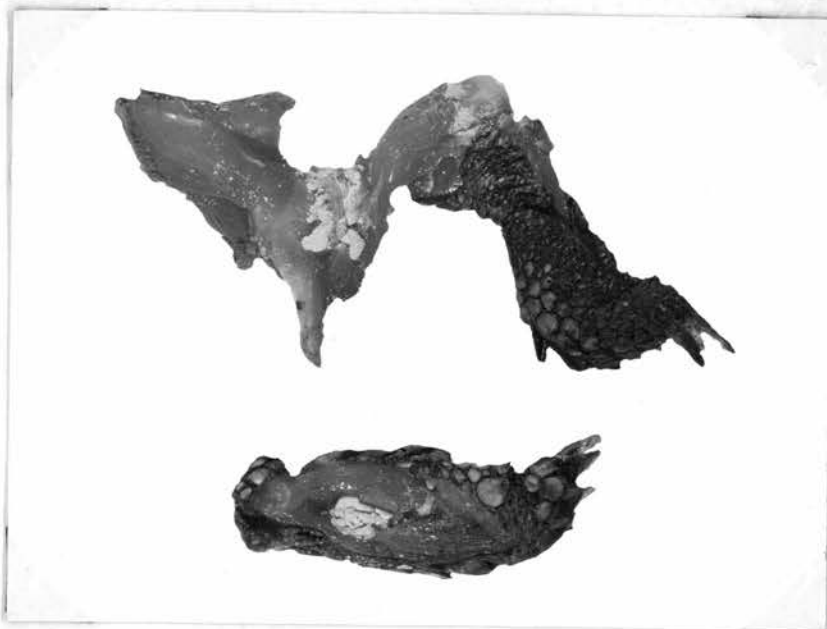
2. Dissection showing uratic deposits at the intervertebral junctions, on the ribs, and at various sites on the legs feet.

Uratic "Gout"



CB51/11 Bosc's Monitor (*Varanus exanthematicus*)

Dissection of underside of the left hind leg showing uratic material distending the capsule of the humero-tibial joint, and displayed in the femoro-pelvic joint.



CB51/44 Moorish Tortoise (*Testudo graeca*)

Uratic deposits in joints of fore and hind limbs.

APPENDIX I

LISTS OF DEATHS AT EDINBURGH ZOOLOGICAL PARK
DURING THE PERIOD 1950 - 1951

e Not examined post-mortem.

1 Examined by Pathology Staff at Royal (Dick)
School of Veterinary Studies.

P 50/

- 1 Patas Monkey
- 2 Slender Loris e
- 3 Chimpanzee 1
- 4 Crab-eating Macaque
- 5 Common Marmoset
- 6 Patas Monkey
- 7 Demidoff's Galago 1
- 8 Hamadryas Baboon
- 9 Hamadryas Baboon
- 10 Chimpanzee e
- 11 Green Monkey 1
- 12 Green Monkey 1

P 51/

- 1 Chimpanzee
- 2 Patas Monkey
- 3 White-crowned Mangabey
- 4 Mona Monkey
- 5 Green Monkey
- 6 Black-tailed Marmoset
- 7 Putty-nosed Monkey
- 8 Demidoff's Galago
- 9 Bosman's Potto
- 10 Ring-tailed Lemur 1
- 11 Brown Woolly Monkey
- 12 Slender Loris

O 50/

- 1 Weasel
- 2 Seal
- 3 Ferret
- 4 Badger
- 5 Long-eared Bat e
- 6 Otter
- 7 Lioness
- 8 Silver Fox
- 9 Sea Lion
- 10 Aard Wolf
- 11 Seal e
- 12 Seal e
- 13 Lioness
- 14 Chinese Palm Civet
- 15 (Domestic Cat)
- 16 Sea Lion
- 17 Leopard
- 18 Palm Civet
- 19 Ferret

O 51/

- 1 Black-backed Jackal
- 2 Chinese Palm Civet
- 3 Crab-eating Fox
- 4 Wolf
- 5 Pine Marten
- 6 Stoat
- 7 Red Fox
- 8 Polar Bear
- 9 Otter
- 10 Seal
- 11 Lion
- 12 Leopard Cat
- 13 Hybrid Wild Cat

APPENDIX I (contd.)

R 50/

- 1 Beaver
- 2 Tree Squirrel
- 3 Rabbit
- 4 Gerbil
- 5 Gerbil
- 6 Gerbil
- 7 Gerbil
- 8 Coypu
- 9 Hamster
- 10 Gerbil
- 11 Rabbit
- 12 Gerbil
- 13 Rat
- 14 Mole Rat
- 15 Rabbit
- 16 Rabbit
- 17 Rabbit
- 18 Rabbit
- 19 Coypu
- 20 Gerbil
- 21 Beaver
- 22 Beaver
- 23 Rabbit
- 24 Gerbil
- 25 Gerbil
- 26 Coypu
- 27 Rabbit
- 28 Mouse
- 29 Gerbil
- 30 Gerbil
- 31 Beaver
- 32 Mouse
- 33 Chipmunk
- 34 Chipmunk
- 35 Gerbil
- 36 Gerbil
- 37 Gerbil
- 38 Golden Hamster
- 39 Rabbit
- 40 Rabbit
- 41 Rabbit
- 42 Rabbit
- 43 Rabbit
- 44 Golden Hamster
- 45 Rabbit
- 46 Rabbit
- 47 Rabbit
- 48 Rabbit e
- 49 Rabbit e
- 50 Rabbit e
- 51 Rabbit e
- 52 Rabbit e

R 51/

- 1 Golden Hamster
- 2 Tree Squirrel
- 3 Gerbil
- 4 Hare
- 5 African Mouse
- 6 Af. Dormouse
- 7 Af. Dormouse
- 8 Crested Porcupine
- 9 Crested Porcupine
- 10 Crested Porcupine
- 11 Crested Porcupine
- 12 Chipmunk 1
- 13 Capybara 1
- 14 Golden Hamster e
- 15 Beaver e
- 16 Long-tail Rat
- 17 Beaver
- 18 Crested Porcupine
- 19 Crested Porcupine
- 20 Crested Porcupine
- 21 Af. Mouse
- 22 Gerbil
- 23 Chipmunk
- 24 Golden Hamster
- 25 Cane Rat
- 26 Chipmunk
- 27 Golden Hamster
- 28 Golden Hamster
- 29 Golden Hamster
- 30 Golden Hamster
- 31 Golden Hamster
- 32 Golden Hamster
- 33 Golden Hamster
- 34 Chipmunk
- 35 Crested Porcupine
- 36 Golden Hamster
- 37 Chipmunk
- 38 Crested Porcupine
- 39 Crested Porcupine
- 40 Crested Porcupine

RF 51/

- 1 Mouse
- 2 Mouse
- 3 Rabbit
- 4 Rabbit
- 5 Rabbit
- 6 Rabbit
- 7 Rabbit
- 8 (not utilised)
- 9 Guinea Pig
- 10 Mouse
- 11 Rabbit
- 12 Rabbit

APPENDIX I (contd.)

RF 51/

- 13 Rabbit
- 14 Rabbit
- 15 Rabbit
- 16 Rabbit
- 17 Rabbit
- 18 Rabbit
- 19 Guinea Pig
- 20 Guinea Pig
- 21 Guinea Pig
- 22 Rabbit
- 23 Rabbit
- 24 Rabbit
- 25 Rabbit
- 26 Rabbit
- 27 Guinea Pig
- 28 Guinea Pig
- 29 Guinea Pig
- 30 Guinea Pig
- 31 Guinea Pig
- 32 Guinea Pig
- 33 Guinea Pig
- 34 Guinea Pig
- 35 Guinea Pig
- 36 Guinea Pig
- 37 Rabbit
- 38 Rat
- 39 Rabbit
- 40 Rat
- 41 Rabbit

U 50/

- 1 Lama 1
- 2 Wild Boar
- 3 Speke's Gazelle
- 4 Wart Hog
- 5 Lama
- 6 Ronaldshay Ram
- 7 Lama
- 8 Lama
- 9 Cross-bred Sheep
- 10 Cross-bred Sheep
- 11 European Bison 1
- 12 Lama
- 13 Barbary Sheep
- 14 Lama

U 51/

- 1 Nigerian Goat
- 2 Harnessed Antelope
- 3 Harnessed Antelope
- 4 Fat-tailed Ram
- 5 Duiker
- 6 Barbary Lamb
- 7 Harnessed Antelope
- 8 European Bison
- 9 Nigerian Goat
- 10 Nigerian Sheep
- 11 Nigerian Sheep 1
- 12 Nigerian Sheep
- 13 Shetland Pony
- 14 Axis Deer
- 15 Donkey Foal

M 50/

- 1 Bennett's Wallaby
- 2 Hairy Armadillo 1
- 3 Bennett's Wallaby
- 4 Bennett's Wallaby

M 51/

- 1 Bennett's Wallaby
- 2 Bennett's Wallaby
- 3 Squirrel Flying Opossum 1
- 4 Bennett's Wallaby 1
- 5 Bennett's Wallaby
- 6 Squirrel Flying Opossum

APPENDIX I

AVES

A 50/

1	Owl	56	Snowy Owl
2	Buzzard	57	Budgerigar
3	Silver Pheasant	58	Tawny Owl
4	Ostrich	59	Mallard Duckling
5	Buzzard 1	60	Chilean Flamingo
6	Eagle Owl 1	61	Young Night Heron
7	Cygnets	62	Amherst Pheasant
8	Buff-backed Heron	63	Canary
9	Snowy Egret	64	Tawny Owl
10	Eider Duck 1	65	Brush Turkey
11	Snowy Egret	66	Guillemot
12	Guinea Fowl	67	Argus Pheasant
13	Coot	68	Finch
14	Night Heron	69	Finch
15	Zebra Finch e	70	Finch
16	Gannet	71	Finch
17	Budgerigar	72	Guillemot
18	Golden Pheasant	73	Finch e
19	Chinese Goose 1	74	Silver Finch 1
20	Dove	75	Spice Finch 1
21	Budgerigar 1	76	Cordon Bleu 1
22	Bare-eyed Cockatoo	77	Cordon Bleu 1
23	Budgerigar	78	Finch 1
24	Chinese Goose	79	Silverbill 1
25	Muscovy Duck	80	Outthroat 1
26	Ruddy Sheldrake	81	Cordon Bleu 1
27	Tawny Owl	82	Whydah 1
28	King Penguin	83	Three-coloured Nun 1
29	Leadbetter's Cockatoo	84	Cordon Bleu 1
30	Green Singing Finch	85	Cordon Bleu 1
31	Swan	86	Combassou 1
32	Green Singing Finch	87	Whydah 1
33	Pekin Bantam	88	Three-coloured Nun 1
34	Budgerigar	89	Firefinch 1
35	Silver Pheasant	90	Spice Finch 1
36	Gannet	91	Finch e
37	Budgerigar	92	Finch e
38	Touraco	93	Finch e
39	Ostrich	94	Finch e
40	Griffon Vulture	95	Finch e
41	Monal Pheasant	96	Finch e
42	Green Singing Finch	97	Finch e
43	Guillemot	98	Finch e
44	Rockhopper Penguin	99	Finch e
45	Silver Pheasant	100	Finch e
46	Golden Oriole	101	Finch e
47	King Penguin	102	Finch e
48	Bullfinch	103	Finch e
49	Chilean Flamingo	104	Finch e
50	Grey Parrot	105	Finch e
51	Gentoo Penguin	106	Finch e
52	Buzzard	107	Finch e
53	Budgerigar	108	Finch e
54	Mallard Duckling	109	Finch e
55	Mallard Duckling 1	110	Finch e

AVES (continued)

A 50/

111	Finch	♂	166	Finch	
112	Finch	♀	167	Khaki Campbell Duck	
113	Finch	♀	168	Finch	
114	Finch	♀	169	Magpie Mannakin	
115	Finch	♀	170	Magpie	
116	Finch	♀	171	Spur-winged Goose	
117	Finch	♀	172	Bronze-naped Pigeon	
118	Finch	♀	173	Young Ibis	
119	Finch	♀	174	Finch	1
120	Finch	♀	175	Finch	1
121	Cuckoo	♀	176	Finch	1
122	Cockatoo	♀	177	Finch	1
123	Wood Pigeon	♀	178	Canary	
124	Silver Pheasant	♀	179	Orange-cheeked Waxbill	
125	Sulphur Crested Cockatoo	♀	180	Cordon Bleu	
126	Call Duck	♀	181	Magpie	
127	Common Gull	♀	182	Red-faced Lovebird	
128	Spice Finch		183	Pigeon	
129	Three-coloured Nun		184	Pigeon	♀
130	Silverbill		185	Grey Parrot	
131	Sarus Crane Chick		186	Gentoo Penguin	
132	Arctic Skua		187	Whistling Tree Duck	
133	Finch		188	Rosella Parrakeet	
134	Muscovy Duck		189	Lavender Finch	
135	Gannet		190	Weaver Bird	
136	Grey Parrot		191	Lavender Finch	
137	Budgerigar		192	Finch	
138	Firefinch		193	Finch	
139	Finch		194	Guinea Fowl	
140	Cockatiel		195	Bul-bul	
141	Jackdaw		196	Domestic Dove	♀
142	Jackdaw		197	Jackdaw	
143	Gannet		198	Crowned Crane	♀
144	Kestrel		199	Domestic Dove	♀
145	Gannet				
146	Finch				
147	Swan				
148	Grey Parrot				
149	Finch	↓			
150	Finch	1			
151	Finch	1			
152	Magpie				
153	Finch	1			
154	Finch	1			
155	Finch	1			
156	Finch	1			
157	Pigeon				
158	Finch	1			
159	Finch	1			
160	Finch	1			
161	Budgerigar				
162	Finch	↓			
163	Finch	1			
164	Finch	1			
165	Finch	1			

A 51/

1	Orange-cheeked Waxbill	
2	Budgerigar	
3	Green Singing Finch	
4	Green Singing Finch	
5	Silver Finch	
6	Domestic Dove	♀
7	Tambourine Dove	♀
8	Ruddy Shelduck	
9	Common Dove	
10	Ruddy Shelduck	
11	Dove	♀
12	Sarus Crane	
13	Call Duck	
14	Crowned Crane	
15	Guillemot	
16	Blue and Yellow Macaw	
17	Mallard	

A 51/

18 Guillemot
19 Whistling Tree Duck
20 Touraco
21 Ostrich
22 Guillemot
23 Swan
24 Swan
25 Lovebird
26 Chilean Flamingo
27 Budgerigar e
28 Ostrich
29 Peahen
30 Java Sparrow
31 Mallard
32 Budgerigar
33 B.T. Crested Touraco
34 Seabright Bantam
35 Common Shelduck
36 Barn Owl
37 Common Pheasant
38 Kestrel
39 Gambossou
40 Blue & Yellow Macaw
41 Chilean Flamingo
42 Ringed Penguin
43 Ringed Penguin
44 Ringed Penguin
45 Ringed Penguin
46 Ringed Penguin
47 Black-headed Conure
48 Red-tailed Finch
49 Ringed Penguin
50 Crowned Crane
51 Red Eyed Dove
52 Ringed Penguin
53 Ringed Penguin
54 Ringed Penguin
55 Ringed Penguin
56 Ringed Penguin
57 M. Weaver
58 Ringed Penguin
59 Bantam
60 Ringed Penguin
61 Fairy Penguin
62 Canary
63 Great Black Cockatoo
64 Amazon
65 Firefinch e
66 Marabou
67 Jackdaw
68 Purple Coot
69 Crested Pelican
70 Ringed Penguin
71 Avadavat
72 Buff-backed Heron
73 Vinaceous Dove
74 Ringed Penguin
75 Ground Thrush

A 51/

76 Outthroat
77 Orange-cheeked Waxbill
78 Ringed Penguin
79 Abyssinian Lanner
80 Snowy Egret
81 Black Bantam
82 King Penguin
83 Ground Hornbill
84 Touraco
85 Ringed Penguin
86 Whydah
87 Kestrel
88 Cygnet
89 Cygnet
90 Tawny Owl
91 Kestrel
92 Kestrel
93 Black-headed Gull
94 Ringed Penguin
95 Golden Pheasant
96 Cygnet
97 Black-headed Ibis
98 Macaroni Chick
99 Black-headed Gull
100 Little Owl
101 King Penguin
102 R.B. Cockatoo
103 Cygnet
104 Cygnet
105 B.H. Ibis 1
106 B.F. Amazon 1
107 Cygnet 1
108 Tawny Owl 1
109 King Penguin Chick 1
110 Fairy Penguin 1
111 Fairy Penguin 1
112 Kestrel e
113 Kestrel e
114 B. H. Ibis 1
115 Black-headed Gull
116 Jackdaw e
117 Kestrel e
118 Blackfoot Penguin 1
119 B. H. Ibis
120 B. H. Ibis
121 Magpie Mannakin e
122 Cockatiel
123 Shama
124 Ribbon Finch
125 Spice Finch
126 Sulphur Crested Cockatoo
127 Barn Owl e
128 Orange-cheeked Waxbill
129 (not utilised)
130 Spice Finch
131 Blue & Yellow Macaw
132 G. B. Waxbill

AVES (continued)

A 51/

- 133 R. C. Waxbill
- 134 R. C. Waxbill
- 135 Tawny Owl
- 136 Chilean Flamingo
- 137 King Penguin
- 138 Gold Coll. Macaw
- 139 Fairy Penguin
- 140 Ground Hornbill
- 141 Eider Duck
- 142 O B. Weaver
- 143 R.H. Lovebird
- 144 Flamingo
- 145 Orange-cheeked Waxbill
- 146 R. C. Waxbill
- 147 R. C. Waxbill
- 148 Grey S. Finch
- 149 P. Whydah
- 150 Am. Eagle Owl
- 151 Bramble Finch
- 152 Sandpiper
- 153 N. P. Bunting
- 154 Canary
- 155 O. C. Parrot
- 156 Whydah
- 157 B.F. Amazon
- 158 Green Plover
- 159 Parakeet
- 160 N. P. Bunting
- 161 Spangled Bantam
- 162 White-bellied Stork
- 163 King Penguin
- 164 Ringed Penguin
- 165 Ringed Penguin
- 166 Raven
- 167 Canary
- 168 Sarus Crane
- 169 Buzzard

REPTILIA and AMPHIBIA

CB 50/

- 1 Two-banded Monitor
- 2 Moorish Tortoise
- 3 Spurred Tortoise 1
- 4 Eyed Monitor
- 5 Agama Lizard 1
- 6 Gaboon Viper
- 7 Moorish Tortoise
- 8 Common Chameleon
- 9 F. N. Chameleon
- 10 Two-banded Monitor
- 11 Agama Lizard
- 12 Water Snake
- 13 Seba's Python
- 14 Moorish Tortoise
- 15 Bearded Lizard 1
- 16 Moorish Tortoise
- 17 Water Snake
- 18 Green Lizard
- 19 Green Lizard
- 20 Green Lizard
- 21 Grass Snake
- 22 Kirtland's Tree Snake
- 23 Grass Snake
- 24 Grass Snake
- 25 Grass Snake e
- 26 Eyed Skink e
- 27 Water Snake e
- 28 Green Lizard e
- 29 Green Lizard e
- 30 Moorish Tortoise e
- 31 Grass Snake e
- 32 Viperine Snake e
- 33 Leopard Tortoise e
- 34 Bearded Lizard e
- 35 Cat Snake e
- 36 Grass Snake
- 37 African Lined Snake
- 38 Agama Lizard
- 39 Crocodile
- 40 Toad
- 41 Beauty Snake e
- 42 Water Snake
- 43 African Lined Snake
- 44 Black-necked Cobra
- 45 Agama Lizard
- 46 Nilotic Monitor
- 47 Basc's Monitor
- 48 Skink
- 49 African Lined Snake
- 50 Plated Lizard
- 51 Giant Skink
- 52 Viperine Snake
- 53 Turtle
- 54 Moorish Tortoise
- 55 Agama Lizard
- 56 Agama Lizard

CB 50/

- 57 Common Chameleon
- 58 Spurred Tortoise
- 59 Tree Frog
- 60 Greenleaf Snake
- 61 Greenleaf Snake
- 62 Spurred Tortoise
- 63 Agama Lizard
- 64 Agama Lizard
- 65 Moorish Tortoise
- 66 Greenleaf Snake
- 67 Moorish Tortoise
- 68 Marbled Tree Frog
- 69 Marbled Tree Frog

CB 51/

- 1 Moorish Tortoise
- 2 Tree Frog
- 3 Estuarine Crocodile
- 4 Plated Lizard
- 5 F. N. Chameleon
- 6 Tree Frog
- 7 Tree Frog
- 8 Plated Lizard
- 9 F. N. Chameleon
- 10 F. N. Chameleon
- 11 Bosc's Monitor
- 12 Flap-necked Chameleon
- 13 " "
- 14 " "
- 15 " "
- 16 " "
- 17 Baby Puff Adder
- 18 Leopard Tortoise
- 19 Flap-necked Chameleon
- 20 Marbled Tree Frog
- 21 Water Snake
- 22 Moorish Tortoise
- 23 Wall Lizard
- 24 Water Snake
- 25 Malayan Tree Frog
- 26 Grass Snake
- 27 Viperine Snake
- 28 Malayan Tree Frog
- 29 Seba's Python
- 30 Flap-necked Chameleon
- 31 Flap-necked Chameleon
- 32 Moorish Tortoise
- 33 Leopard Tortoise
- 34 Flap-necked Chameleon
- 35 Common Chameleon
- 36 Swan River Toad
- 37 Night Adder
- 38 Bell's Tortoise 1

REPTILIA and AMPHIBIA (contd.)

CB 51/

- 39 Dark Green Snake e
- 40 Moorish Tortoise e
- 41 Dark Green Snake e
- 42 Tesselated Snake e
- 43 Moorish Tortoise
- 44 Moorish Tortoise
- 45 Eyed Lizard
- 46 African Lined Snake
- 47 Dark Green Snake
- 48 African Bullfrog
- 49 Seba's Python
- 50 Moorish Tortoise
- 51 Grass Snake
- 52 Moorish Tortoise
- 53 Moorish Tortoise
- 54 Grass Snake
- 55 Black-necked Cobra
- 56 Adder
- 57 Dark Green Snake
- 58 Blanding's Turtle
- 59 Af. Sharp-snouted Snake
- 60 Grass Snake
- 61 Nilotic Monitor
- 62 African Bullfrog
- 63 Black-White Cobra
- 64 Gecko
- 65 Baby Puff Adder
- 66 Tesselated Snake
- 67 Sand Lizard
- 68 African Bullfrog
- 69 African Bullfrog
- 70 African Bullfrog
- 71 Smooth Snake
- 72 European Sand Tortoise
- 73 Black-necked Cobra
- 74 Clawless Gecko
- 75 Moorish Tortoise
- 76 Moorish Tortoise
- 77 Leopard Tortoise
- 78 Common Chameleon
- 79 African Bullfrog
- 80 African Bullfrog

APPENDIX IISome Notes on Occurrences during 1952Pasteurella Pseudotuberculosis Infection

Pasteurella pseudotuberculosis rodentium was isolated from the lesions found on post-mortem examination in the intestines, liver and spleen of a Mona Monkey, two Patas Monkeys, a Violet Plantain Eater, two Sardinian Starlings and a Banded Aracari. Another Aracari and a Green Billed Toucan, dying at the same time as the other birds, showed a similar ulcerative condition of the intestine and focal hepatic necrosis but gave negative bacteriological examinations.

The outbreak among the monkeys coincided with a period when spoiled dried fruit was being fed. At a later date this same fruit was included in the birds' diet and it was only when the Senior Bird Keeper referred to the fact that fruit-eating birds alone were dying that the food was examined. It was found to be very 'dirty' fruit, and appeared to contain rat faeces. Bacteriological examination of the fruit isolated several other *Pasteurellae* from the sample but not *pseudotuberculosis rodentium*. Deaths ceased about two weeks after the fruit was removed from the birds' diet, however, and there is little doubt in the writer's mind that this was the source of infection.

Photographs of the lesions in the Mona Monkey are appended.

Gray (1936) describes this disease as fairly frequent in cage and aviary birds and Beaudette (1940) quotes a report of the disease in Toucans by Urbain and Nouvel.

Tuberculosis in a Monkey

Advanced pulmonary tuberculosis was found in an emaciated young female Toque Monkey, destroyed on suspicion. It had recently arrived with two others of the same species from an Asiatic zoological park. In view of the difficulty of employing Fox's tuberculin test, which involves repeated temperature taking (Fox, 1923), the intra-palpebral method described by Schroeder (1938) was employed. The monkeys were tested twice at an eight week interval with negative results. Fox (1939) discusses various other methods of tuberculin testing in Primates, most of which he has found to be of little value. Hamerton (1938, 1936) discusses methods used at London.

Disease in Penguins

A consignment of King Penguins arrived early in the year in comparably poor condition to the group of Ringed Penguins in 1951. A number of deaths from Aspergillosis occurred, and on several occasions mycotic colonies were found on the lining of the stomach.

Several cases of parasitic gastritis were also seen, a catarrhal exudate spotted with haemorrhages covering much of the glandular and pyloric areas.

One case of severe uratic 'gout' occurred, deposits of the substance being found in the tendon sheaths as well as the joint capsules. There was no evidence of 'bumble foot.'

Photographs of these conditions are appended.

Disease in Tortoises

Further cases of unexplained disease of the urinary tract occurred in Tortoises during the early months of 1952. Photographs are appended of a Spurred Tortoise where 'sunflower' bodies were very clearly demonstrated in the kidney tissue, and

pronounced "arthritic gout" was evident.

Later the Moorish Tortoises were transferred to another cage in which they had more room for exercise, and a more readily accessible pond. Since that time deaths have been rare, which suggests that an inadequate water intake may have been connected with the condition.

Pseudotuberculosis (*Pasteurella pseudotuberculosis*
rodentium Infection)

P52/1. Mona Monkey (*Cercopithecus mona*)



1. The Spleen, showing large caseous nodules.

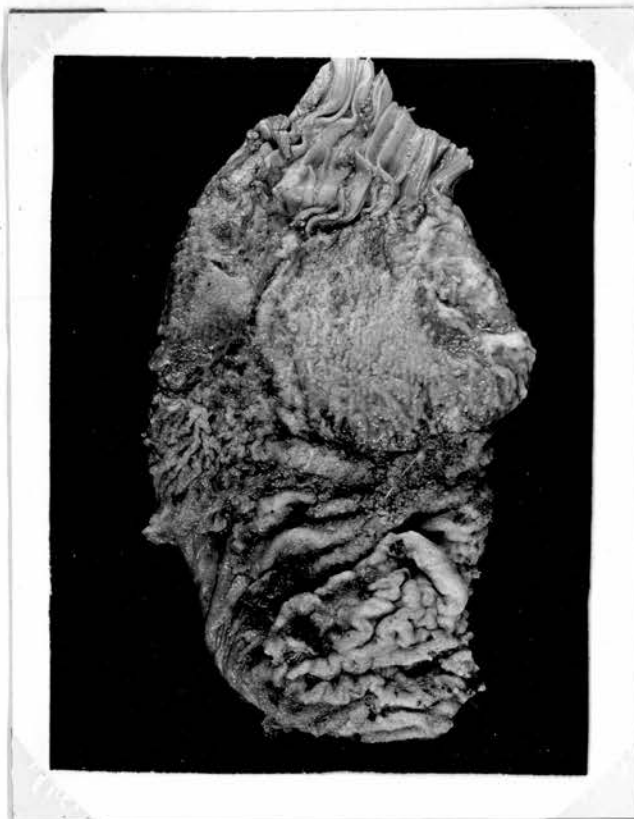


2. The Liver, showing multiple caseous foci.

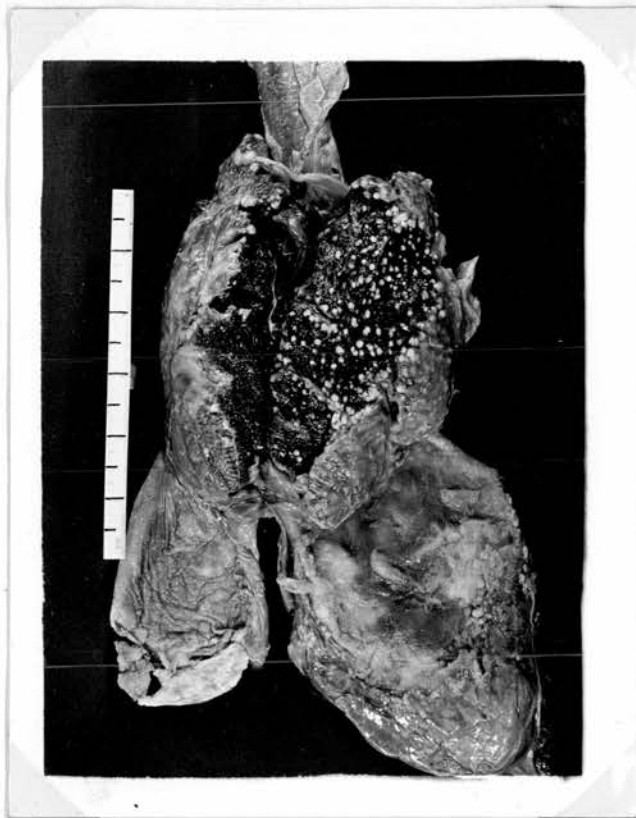
Gastritis in Penguins



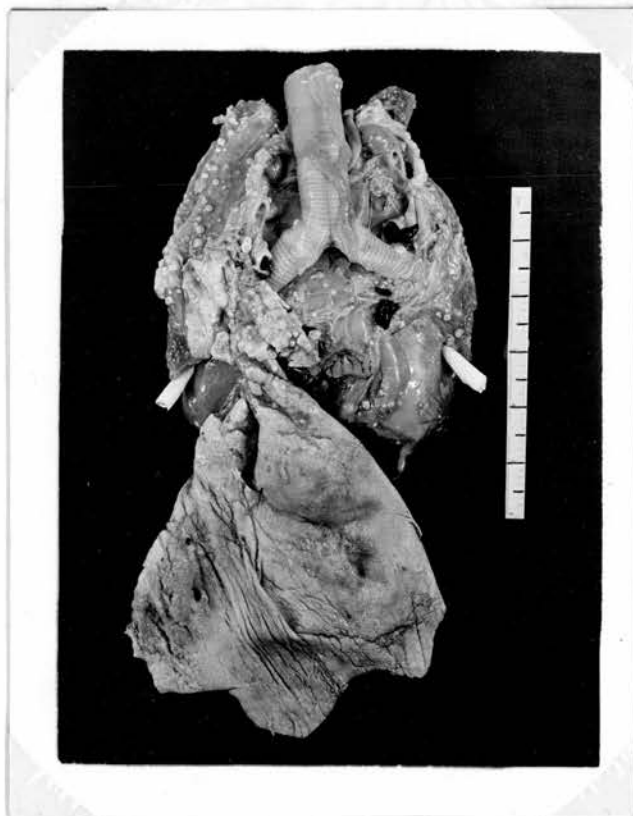
Stomach of King Penguin showing small mycotic colonies in the glandular area.



A52/70. Stomach of King Penguin, showing cararrhal exudate on the glandular and pyloric areas, the latter being spotted with small haemorrhages. Nematode parasites were found beneath the exudate.

Mycosis

A52/64. King Penguin (*Aptemodytes patagonica*). Dorsal view of lungs and abdominal airsacs after removal from the body. A section of the pleura has been cut away from each lung.



A52/57. King Penguin. Ventral view of lungs of right abdominal airsac, which is severely affected. The markers show the air passages from lungs to airsacs.

Uratic "Gout"

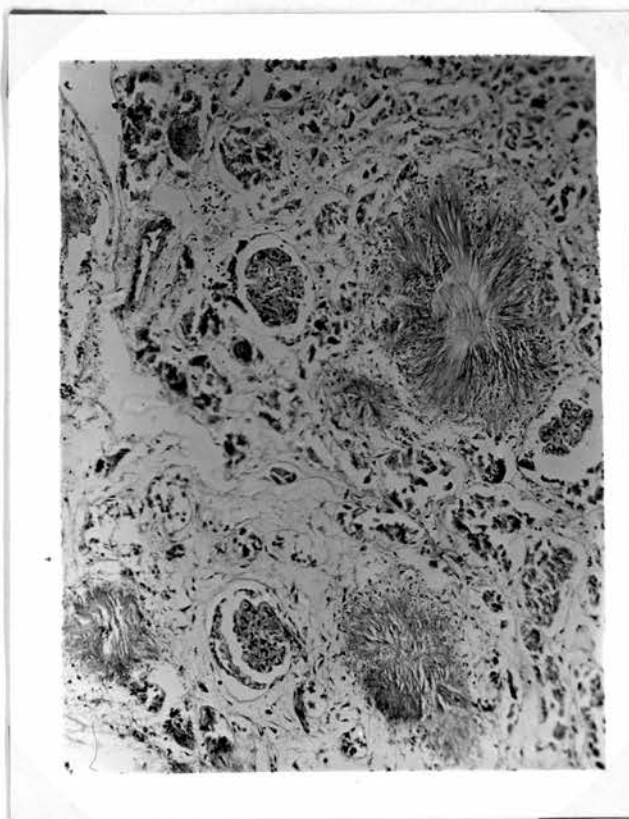
A52/72. King Penguin (*Aptenodytes patagonica*)



Dissection showing urate deposits in the joints and tendon sheaths of the leg.

Uratic "Gout"CB52/5. Spurred Tortoise (*Testudo sulcata*)

1. Scapulo-humerus joint displayed to show urate deposits.



2. Microphotograph of kidney tissue showing 'sunflower' bodies etc. x 130. Haematoxylin-Eosin.

APPENDIX IIILIST of INSTITUTIONS RECEIVING SCIENTIFIC MATERIAL

Hannah Dairy Research Institute, Ayr.	Skin specimens.
Public Health Laboratory Service, Nottingham	Tortoise faeces.
Wool Industries Research Association, Leeds	Skin specimens.
University of St. Andrews Anatomy Department Natural History Department	Skulls
University of Southampton	Skeletons
Royal (Dick) School of Veterinary Studies Anatomy Department Biology Department	Kidneys Amphibian skeletons
University College, Exeter	Skulls of birds and mammals. Marsupial skeletons.
University of Edinburgh Anatomy Department Zoology Department	Mammalian lungs Porcupine carcasses Parasite material Wild rodents.
Rowett Research Institute, Aberdeen.	Ruminant stomachs.
Edinburgh Royal Infirmary	Primate hearts.
Glasgow University, Chemistry Dept.	Fat samples.
Royal Scottish Museum	Specimens for mounting.
Royal Botanic Gardens, Edinburgh.	Mycotic lung tissue.

Replies to queries have been sent to the Colonial Products Advice Bureau, the Animal Health Trust, the University Federation of Animal Welfare, the National Veterinary Medical Association and the Medical Research Council.

Letters have also been written to numerous private individuals requiring advice on the keeping of tortoises, budgerigars and other pets.

CLASSIFICATION

drawn from

LIST OF THE VERTEBRATED ANIMALS EXHIBITED IN THE GARDENS OF
THE ZOOLOGICAL SOCIETY OF LONDON 1828-1927.

Note: Only those orders including species mentioned in
the text are listed.

CLASS MAMMALIA

O. PRIMATES	.....	Apes, Monkeys, Lemurs, Galagos, etc.
O. LIPOTYPHILA	.....	Hedgehogs.
O. CHIROPTERA	.....	Bats.
O. CARNIVORA	.....	Cats, Dogs, Civets, Mongooses, Badgers, Hyaenas, Raccoons, etc.
O. PINNIPEDIA	.....	Seals, Sea lions, etc.
O. RODENTIA	.....	Mice, Rats, Gerbils, Porcupines, Coypus, etc.
O. LAGOMORPHA	.....	Rabbits and Hares.
O. PROBOSCIDEA	.....	Elephants.
O. PERISSODACTYLA	.....	Horses, Zebras, Rhinoceroses, Tapirs, etc.
O. ARTIODACTYLA	.....	Cattle, Sheep, Deer, Antelope, etc.
O. XENARTHRA	.....	Armadillos, etc.
O. MARSUPIALIA	.....	Wallabies, Kangaroos, etc.

CLASS AVES

O. PASSERIFORMES	... Finches, etc.	O. ARDEIFORMES	... Herons, Storks, Ibis, Egret, etc.
O. PICIFORMES	... Toucans, etc.	O. BALEARICIFORMES	... Cranes
O. COCCYGIIFORMES	... Cuckoo, Touracos, etc.	O. CHARADRIIFORMES	... Sandpiper, Plovers etc.
O. CORACIIFORMES	... Hornbills, etc.	O. LARIFORMES	... Skuas, Gulls, Tern etc.
O. PSITTACIFORMES	... Parrots, Macaws, Cockatoos, etc.	O. ALCIFORMES	... Razorbills, Guillemot, Puffin.
O. STRIGIFORMES	... Owls.	O. SPHENISCIFORMES	... Penguins
O. ACCIPITRIFORMES	... Eagles, Kestrels, Vultures, etc.	O. PODICIPIDIFORMES	... Grebes
O. PELECANIFORMES	... Pelicans, Gannets, etc.	O. RALLIFORMES	... Rails, Coot, Moorhen, etc.
O. PALAMEDEIFORMES	... Screamers.	O. COLUMBIFORMES	... Pigeons, Doves.
O. RHODENICOPTERIFORMES	... Flamingoes	O. GALLIFORMES	... Fowl, Pheasant, Turkey, etc.
O. ANSERIFORMES	... Ducks, Geese, Swans.	O. CASUARIIFORMES	... Cassowaries
		O. RHEIFORMES	... Rheas
		O. STRUTHIONIFORMES	... Ostriches

CLASS REPTILIA

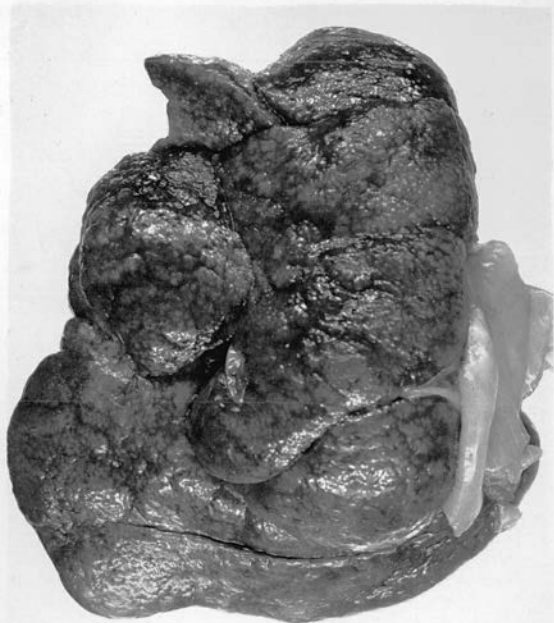
O. TESTUDINATA	.....	Tortoises, Turtles, Terrapins.
O. LORICATA	.....	Alligators, Crocodiles, etc.
O. SAURIA	.....	Lizards, Monitors, Geckos, etc.
O. SERPENTES	.....	Snakes.



3462

juice 02/11/51. leopard cat.

F.R.A.



2460-

June 22/4/51

Leopard Cat.

1884

15. N. 2.5.